

State of California  
The Resources Agency  
DEPARTMENT OF WATER RESOURCES  
San Joaquin District

**SAN JOAQUIN VALLEY  
DRAINAGE MONITORING PROGRAM  
1998**

District Report

July 2002

Gray Davis  
Governor  
State of California

Mary D. Nichols  
Secretary for Resources  
The Resources Agency

Thomas M. Hannigan  
Director  
Department of Water Resources

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## FOREWORD

The purpose of this annual report is to share valuable information about agricultural drainage water. This report is distributed to interested parties to expand the understanding of drainage problem areas, groundwater impacts and water quality trends resulting from agricultural drainage practices.

The Drainage Monitoring and Evaluation Program is a cooperative effort of State, federal and local agencies. Data on the quality and quantity of drainage water and aerial extent of shallow groundwater is collected, assembled, analyzed, and disseminated. DWR collects shallow groundwater data and monitors about thirty drainage sump systems for flow and water quality constituents including sodium, calcium, total dissolved solids, selenium and other targeted constituents. The constituents are investigated for trends that show the results of irrigation and drainage management practices. Data from over ten other agencies are combined with DWR data and summarized in this report.

In addition, a shallow groundwater map is drawn from measurements of over 1,000 wells to show groundwater levels to identify present and potential problem drainage areas due to encroachment into the root zone.

To improve its ongoing data-gathering efforts, the Department of Water Resources invites water resources specialists to participate in discussing and commenting on the scope of this report.

Paula J. Landis, Chief  
San Joaquin District

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## INTRODUCTION

In 1959, the California Department of Water Resources began monitoring agricultural drainage water in the San Joaquin Valley. Initial monitoring efforts (1959-1963) focused on mineral analyses. In 1963, the monitoring program became part of the San Joaquin Drainage Investigation and included analyses for pesticides in both surface and subsurface drainage waters. From 1966 to 1969, intensive nutrient sampling became a part of the investigation.

Although the San Joaquin Drainage Investigation ended in 1970, monitoring continued as a separate departmental activity until 1975 when the Department of Water Resources, the U.S. Bureau of Reclamation, and the State Water Resources Control Board formed the Interagency Drainage Program. The program continued until 1979 when monitoring resumed as a separate activity under the DWR's Agricultural Drainage Program.

Focusing national attention on drainage and drainage-related problems was the discovery in 1983 of migratory bird deaths and deformities linked to high selenium levels in drainage water at Kesterson Reservoir, the terminus of the San Luis Drain. This discovery resulted in an interagency drainage study.

In 1984, the San Joaquin Valley Drainage Program was established to investigate and identify possible solutions to drainage and drainage-related problems. The SJVDP is a cooperative federal-State program established by the Secretary of the Interior and the Governor of California. Cooperating agencies are DWR, California Department of Fish and Game, USBR, U.S. Fish and Wildlife Service, and the U.S. Geological Survey. The SJVDP developed a comprehensive study entitled, *A Management Plan for Agricultural Subsurface Drainage and Related Problems on the Westside San Joaquin Valley*, also known as the *Rainbow Report (September 1990)*. This report summarizes the results of subsurface agricultural drainage problems and presents a plan for managing drainage problems.

In 1991, federal and State agencies initiated the San Joaquin Valley Drainage Implementation Program to pick up where SJVDP left off. Four federal agencies (USBR, USFWS, USGS, and Natural Resources Conservation Service) and four State agencies (DFG, DWR, Department of Food and Agriculture, and SWRCB) signed a memorandum of understanding and released an implementation strategy in December 1991. They agreed to (1) work together and identify specific tasks associated with responsible parties, (2) seek needed funding and authority, and (3) set schedules for implementing all components of the SJVDP 1990 Plan.

The MOU and all the agencies involved recognize the success of the program depends upon local districts and irrigators to carry out effective drainage management measures. Because drainage is a regional problem, federal and State agencies will continue to coordinate efforts. The DWR drainage monitoring program is continuously being evaluated and modified to meet the needs of the implementation strategy.

## THE DRAINAGE PROBLEM

The San Joaquin Valley, one of the world's most productive agricultural regions, has experienced mounting problems with the management and disposal of agricultural drainage water.

The drainage problem is an outgrowth of naturally saline soils and imported water, as well as the valley's distinctive geological makeup, which prevents effective natural drainage in certain areas. Soils on the western side of the valley are derived from the marine sediments that make up the Coast Range. These soils, high in salts and trace elements, are similar to those that occur in a marine environment. In addition, much of the valley is underlain by a shallow, clay layer that obstructs vertical movement of irrigation water. As salts and minerals from surface soils are leached into the groundwater, the water table rises to within a few feet of the surface and into the root zone. Unless this water is removed, crops growing in these soils eventually die.

In the late 1940s, farmers began installing subsurface drains in fields with drainage problems. By 1965, 330 miles of subsurface drains and 750 miles of open ditch drains were in operation in the valley delivering drainage water to evaporation ponds and other discharge sites. With this drainage network in operation, the main problem became how to manage and dispose of the salty drain water.

The original plan was to construct a master drain (the San Luis Drain) to collect the water and route it out of the valley into the Sacramento-San Joaquin River Delta. By 1973, an 87-mile-long section of the San Luis Drain was receiving irrigation runoff and discharging into Kesterson Reservoir. The plan was to extend the drain north to a discharge site in the Delta. Kesterson Reservoir was to regulate discharges going to the Delta and provide a wetland habitat. The San Luis Drain was never completed and drainage accumulated at Kesterson Reservoir. In 1982, federal studies reported high selenium levels in fish taken from Kesterson. In 1983, federal-State studies determined that the bioaccumulation of selenium was causing deformities in embryos of waterfowl nesting at the reservoir. In 1985, the U.S. Department of the Interior ordered a halt to drainage water discharges into the San Luis Drain and Kesterson Reservoir, even though irrigation water deliveries to west side agricultural lands continued.

Today, the future of the master drain remains in doubt. Practices of disposing and managing drainage water are being scrutinized for their impacts on the environment. Management practices such as source control, drainage reuse, groundwater management, integrated on-farm drainage management, and others identified in the *Rainbow Report* are being implemented. Monitoring of shallow groundwater and agricultural drainage water is an integral activity to determine the effectiveness of these management practices.

## DRAINAGE PROBLEM AREAS

The San Joaquin Valley is a rich agricultural region that encompasses large areas with high water tables. Irrigation practices, cropping patterns, seepage from unlined ditches or ponds, soil type, geology, and other factors influence the elevations of these water tables. Since the importation of water for irrigation, inadequate drainage and accumulating salts have been persistent problems in parts of the valley. The poor natural drainage conditions, coupled with rising groundwater levels and increasing soil salinity, have meant that various soils could no longer produce crops and some farms within the problem area have been abandoned.

In this report "present problem area" is defined as a location where the water table is within 5 feet of the ground surface at any time during the year. A "potential problem area" indicates the water table is between 5 and 20 feet below the ground surface. Present and potential drainage problem areas are established by planimetry within specific intervals from DWR's annual "Present and Potential Drainage Problem Area" map (Plate 1).

A history of how Plate 1 was produced shows the limitations of Table 1, 1987-1990. In the mid-1990's, DWR produced maps for the years 1987 through 1991. The first map was based on generalizations with the intent of covering as large an area as possible. The initial data for the 1987 map were sparse, but even less information was available for the 1988-1990 maps. As a result, vast areas were subject to interpolations and estimates. A canvass for additional groundwater data for the transition period, 1988-1990, could not be conducted since these maps were drawn long after the original data was collected; consequently, comparisons should not be made for this series of maps.

Beginning with the 1991 map, an effort was made to standardize the methods of data collection so that comparisons could be made and trends analyzed. Study area boundaries were drawn and a relatively stable network of monitoring wells was established. Water level data from newly drilled monitoring wells became part of this network. The 1991-1998 data (Table 2) and subsequent maps are the only representations that can be used for comparison.

In preparing Plate 1, DWR did not take into account items such as existing drainage systems, wildlife refuges, urban areas, pasture land, native vegetation, data-poor areas, and the outer boundary. This report provides information on the extent of drainage conditions; therefore, other factors must be considered when making projections about areas that will require drainage systems in the future.

TABLE 1  
ACREAGE OF PRESENT AND POTENTIAL DRAINAGE PROBLEMS  
1987-1990

Depth to Groundwater	1987*	1988	1989	1990
<b>Kern Sub-Basin</b>				
0 to 5 ft	59,000	13,000	16,000	15,000
5 to 10 ft	97,000	134,000	130,000	114,000
10 to 15 ft	174,000	58,000	96,000	87,000
>15 ft		9,000	27,000	19,000
Unaccounted**		110,000	56,000	95,000
<b>TOTAL</b>	<b>330,000</b>	<b>324,000</b>	<b>325,000</b>	<b>330,000</b>
<b>Tulare Sub-Basin</b>				
0 to 5 ft	263,000			92,000
5 to 10 ft	87,000	40,000	53,000	172,000
10 to 15 ft	16,000			
>15 ft				
Unaccounted**		326,000	313,000	101,000
<b>TOTAL</b>	<b>366,000</b>	<b>366,000</b>	<b>366,000</b>	<b>365,000</b>
<b>Westlands Sub-Basin</b>				
0 to 5 ft	109,000	18,000	11,000	27,000
5 to 10 ft	135,000	229,000	258,000	205,000
10 to 15 ft	166,000	104,000	88,000	65,000
>15 ft		58,000	53,000	10,000
Unaccounted**				105,000
<b>TOTAL</b>	<b>410,000</b>	<b>409,000</b>	<b>410,000</b>	<b>412,000</b>
<b>Grasslands Sub-Basin</b>				
0 to 5 ft	255,000	132,000	126,000	74,000
5 to 10 ft	78,000	206,000	207,000	143,000
10 to 15 ft	79,000	58,000	59,000	65,000
>15 ft		16,000	20,000	17,000
Unaccounted**				110,000
<b>TOTAL</b>	<b>412,000</b>	<b>412,000</b>	<b>412,000</b>	<b>409,000</b>
<b>TOTALS</b>				
0 to 5 ft	686,000	163,000	153,000	208,000
5 to 10 ft	397,000	609,000	648,000	634,000
10 to 15 ft	435,000	220,000	243,000	217,000
>15 ft	0	83,000	100,000	46,000
Unaccounted**	0	436,000	369,000	411,000
<b>TOTAL AREA</b>	<b>1,518,000</b>	<b>1,511,000</b>	<b>1,513,000</b>	<b>1,516,000</b>

*Variations in total result from rounding of numbers.*

\* Spring 1987 map shows 0-5, 5-10, and 10-20 feet to water.

\*\* Acreage where data is insufficient to include any depth to water interval.

**TABLE 2**  
**ACREAGE OF PRESENT AND POTENTIAL DRAINAGE PROBLEMS**  
**1991-1998**

Depth to Groundwater	1991	1992	1993	1994	1995	1996	1997	1998
<b>Kern Sub-Basin</b>								
0 to 5 ft	40,000	34,000	24,000	10,000	32,000	50,000	58,000	83,820
5 to 10 ft	121,000	172,000	126,000	148,000	173,000	163,000	182,000	194,787
10 to 15 ft	152,000	84,000	162,000	137,000	115,000	82,000	78,000	77,489
15 to 20 ft	15,000	40,000	17,000	32,000	8,000	31,000	8,000	0
TOTAL	328,000	330,000	329,000	327,000	328,000	326,000	326,000	356,097
<b>Tulare Sub-Basin</b>								
0 to 5 ft	119,000	189,000	199,000	131,000	195,000	221,000	301,000	264,142
5 to 10 ft	244,000	121,000	135,000	212,000	157,000	130,000	61,000	19,844
10 to 15 ft	2,000	54,000	30,000	23,000	11,000	15,000	2,000	0
15 to 20 ft	0	1,000	0	0	0	0	0	0
TOTAL	365,000	365,000	364,000	366,000	363,000	366,000	364,000	283,986
<b>Westlands Sub-Basin</b>								
0 to 5 ft	38,000	110,000	75,000	34,000	126,000	104,000	228,000	278,161
5 to 10 ft	201,000	160,000	172,000	194,000	150,000	205,000	90,000	94,440
10 to 15 ft	85,000	69,000	87,000	96,000	65,000	58,000	49,000	19,632
15 to 20 ft	85,000	73,000	77,000	85,000	68,000	41,000	41,000	0
TOTAL	409,000	412,000	411,000	409,000	409,000	408,000	408,000	392,234
<b>Grasslands Sub-Basin</b>								
0 to 5 ft	114,000	136,000	147,000	146,000	166,000	164,000	156,000	235,300
5 to 10 ft	184,000	150,000	131,000	128,000	144,000	153,000	186,000	117,285
10 to 15 ft	72,000	77,000	99,000	86,000	64,000	59,000	44,000	39,212
15 to 20 ft	42,000	46,000	33,000	51,000	35,000	33,000	22,000	6,772
TOTAL	412,000	409,000	410,000	411,000	409,000	409,000	408,000	398,568
<b>TOTALS</b>								
0 to 5 ft	311,000	469,000	445,000	321,000	519,000	539,000	743,000	861,423
5 to 10 ft	750,000	603,000	564,000	682,000	624,000	651,000	519,000	426,356
10 to 15 ft	311,000	284,000	378,000	342,000	255,000	214,000	173,000	136,334
15 to 20 ft	142,000	160,000	127,000	168,000	111,000	105,000	71,000	6,772
TOTAL AREA	1,514,000	1,516,000	1,514,000	1,513,000	1,509,000	1,509,000	1,506,000	1,430,885

*Variations in total result from rounding of numbers.*

## 1998 DRAINAGE-MONITORING PROGRAM

DWR's San Joaquin Valley drainage-monitoring activities for 1998 consisted of collecting water samples from 25 subsurface and 2 surface drainage sums for the stations listed in Table 3.

Figure 1 provides an overview of the sampling area locations. Because DWR monitors only the Central and Southern Areas (Figures 2 and 3, respectively) the Northern Area stations are not included in this report.

TABLE 3  
DRAINAGE MONITORING STATIONS  
1998

<u>Central Area</u>		<u>Southern Area</u>
BVS	6016	CCN** 3550
BVS	8003	CNR 0801
CTL*	4504	COC 4126
DPS	1367	COC 5329
DPS	2535	ERR 7525
DPS*	3235	ERR 8429
DPS	3465	ERR 8641
DPS	4616	GSY 0855
FBH	2016	HCH** 7439
FBH	8061	LNW 5454
HMH	7516	LNW 5467
		LNW 6459
		LNW 6467
		SFD 2727
		STC** 3505
		STC 5436
		STC** 6467
		VGD 3906
		VGD 4406
		VGD 5412

\*Surface drain

\*\*Inoperative in 1998

*Insert:*

- Figure 1, Overview of Sampling Area Locations (p. 7)
- Figure 2, Central Area Drain Locations (p. 8).
- Figure 3, Southern Area Drain Locations (p. 9).

### Flows

Drainage flow data is collected from sumps with functional flow meters. Table 4 lists the 1998 subsurface drain flows in acre-feet. Many drains receive groundwater from areas outside the drainage pipe collector network. As a result, one drainage sump may act as a collector point for six or more systems. Depending on the soil surrounding the drain, one month's flow may consist of part of the previous months irrigation; therefore, caution should be exercised in using these results.

TABLE 4  
SUBSURFACE DRAIN FLOWS  
1998  
(acre-feet)

Station	Area Tiled (acres)	Jan - Mar 12 11	Mar - May 12 20	May - July 21 9	July - Sept 10 11	Sept - Nov 12 10	Nov 11- 12-Jan-99
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#### Central Area

BVS 6016	740	23.1	242.2	98.0	81.2	3.7	-
BVS 8003	110	-	11.3	16.8	15.7	-	323.8
DPS 1367	120	-	48.7	49.4	45.4	29.4	30.0
DPS 2535	320	-	-	23.0	27.4	-	368.6
DPS 3465	160	-	21.2	22.7	33.3	-	687.3
DPS 4616	140	-	-	-	-	-	-
FBH 2016	81	-	-	21.6	13.0	-	418.2
FBH 8061	320	-	11.1	33.8	-	-	27.4
HMH 7516	320	-	-	-	-	-	-

#### Southern Area

CCN 3550*	880	-	-	-	-	-	-
CNR 0801	-	-	-	-	-	-	-
COC 4126	-	-	-	-	-	-	-
COC 5329	-	-	-	-	-	-	-
ERR 7525	220	-	61.3	-	22.0	-	0.0
ERR 8429	-	-	-	133.0	163.1	91.9	61.0
ERR 8641	258	-	8.0	26.0	31.6	21.1	6.4
GSY 0855	60	-	-	-	-	15.5	9.7
HCH 7439*	-	-	-	-	-	-	-
LNW 5454	-	4.8	7.8	-	202.5	26.9	-
LNW 5467	-	-	-	-	-	-	-
LNW 6459	581	67.5	-	21.1	48.9	38.8	21.3
LNW 6467	1,420	21.6	-	25.1	118.1	36.0	21.1
SFD 2727	120	6.4	17.0	13.9	-	-	-
STC 3505*	140	-	-	-	-	-	-
STC 5436	153	-	-	-	-	-	-
STC 6467*	124	-	-	-	-	-	-
VGD 3906	870	-	-	-	-	-	-
VGD 4406	310	-	-	-	-	-	-
VGD 5412	275	-	-	-	-	-	-

- Denotes insufficient data or no reading.

\*Inoperative in 1998.

### Mineral Constituent Concentrations

Drainage water contains dissolved mineral substances which include sulfates, chlorides, carbonates, and bicarbonates of the elements calcium, magnesium, sodium, and potassium. Salinity is the dissolved mineral concentrate in water, which is commonly measured as either total dissolved solids (TDS) in milligrams per liter (mg/L) or electrical conductivity (EC) in microsiemens per centimeter ( $\mu\text{S}/\text{cm}$ ). The amount and percentage of the mineral constituents found in subsurface agricultural drainage water vary from location to location in the San Joaquin Valley (Table 5). The areas with drainage water high in sodium will have a direct impact upon the water's reuse for irrigation of agricultural crops and potentially reduce the crop yield.

TABLE 5  
SUMMARY OF MINERALS DETECTED  
1998  
(milligrams per Liter)

Element	Subsurface Drains				Surface Drains			
	Minimum	Maximum	Arithmetic Average	Geometric Mean	Minimum	Maximum	Arithmetic Average	Geometric Mean
<u>Central Area</u>								
Boron	4.4	49.0	13.8	10.3	0.24	8.8	4.3	2.0
Calcium	265	642	458	447	16	433	211	94
Magnesium	28	409	174	149	6	116	58	31
Nitrate	12	273	72	46	0.15	41	18	6
Sodium	451	3,490	1,184	998	25	866	398	181
TDS	2,604	10,300	5,631	5,223	150	4,140	2,099	949
EC ( $\mu\text{S}/\text{cm}$ )	3,800	12,300	7,090	6,692	264	5,610	2,842	1,431
SAR	5.1	35.5	11.7	10.2	1.4	15.4	6.2	4.4
<u>Southern Area</u>								
Boron	1.2	60.3	18.2	10.5				
Calcium	90	1,050	398	346				
Magnesium	34	799	257	205				
Nitrate	1.6	316	43	25				
Sodium	508	9,050	3,134	2,447				
TDS	3,030	28,600	11,429	9,682				
EC ( $\mu\text{S}/\text{cm}$ )	3,770	35,300	14,000	12,035				
SAR	6.3	84.0	30.7	25.3				

No surface drains within the Southern Area.

Water high in TDS and chloride can lead to crop tissue burns if applied during germination. Table 6 presents the minimum and maximum TDS values, along with two types of averages: the arithmetic average and geometric mean. The arithmetic average is the average of all obtained data for the given year. The geometric mean, largely used by regulatory agencies, provides an average of central tendency that is less influenced by spiked values in the data set.

TABLE 6  
 TOTAL DISSOLVED SOLIDS IN SUBSURFACE DRAINS  
 1986-1998  
 (milligrams per Liter)

<u>Arithmetic Average</u> <u>Geometric Mean</u>													1998	
1986	1987	1988	1989	1990	1991	1992	1993	1994	1996	1997	1998	Min	Max	
<u>Central Area</u>														
5,898	6,216	5,584	5,462	5,458	5,846	5,311	5,736	5,634	5,407	5,299	5,631	2,604	10,300	
5,391	5,603	5,021	4,918	4,954	5,193	4,707	5,165	5,003	4,848	4,912	5,223			
<u>Southern Area</u>														
13,708	17,297	14,408	13,318	14,038	13,554	13,306	13,613	12,868	9,771	11,325	11,521	3,030	28,600	
8,934	11,979	9,423	8,778	9,286	8,895	8,529	8,900	8,531	6,936	8,503	9,757			

No data collected in 1995.

In practice, EC is a simple measurement that can be used to indicate TDS for a given water at a specific site. EC is a measure of the ability to conduct an electrical current through a given solution. The strength of the current is dependent upon the temperature, type, and concentration of ions within the solution. The standard practice, as used in this report, is to adjust EC measurements to 77°F (25°C). EC levels for 1998, in both the Central and Southern subsurface drains varied from 3,800 to 12,300 µS/cm and 3,770 to 35,300 µS/cm, respectively. EC results for both surface stations included an arithmetic average of 2,842 µS/cm with a maximum level of 5,610 µS/cm (DPS 3235).

With respect to water reuse for irrigation, two factors must be taken into account: EC and the sodium adsorption ratio (SAR). The SAR is widely used for estimating water permeability problems. The high sodium in a high SAR value water replaces the more beneficial calcium and magnesium ions in the soil. This exchange alters the soil structure causing the soil to slake, resulting in a loss of porosity, and thus reducing the infiltration rate of the applied water through the soil. To evaluate a potential permeability problem, SAR values are used in combination with EC values. The following equation distinguishes the elements associated with SAR values.

$$\text{SAR} = \frac{\text{Na}^+}{\sqrt{\frac{(\text{Ca}^{+2}) + (\text{Mg}^{+2})}{2}}}$$

Where  $\text{Na}^+$ ,  $\text{Ca}^{+2}$ , and  $\text{Mg}^{+2}$  represent the concentrations in milliequivalents per liter of the respective ions. In general, irrigation waters having SAR values less than 3 are low risk. Although some salt tolerant crops may have SAR values as high as 16, considerable care is advised for values greater than 6 when reusing agricultural drainage water for irrigation purposes.

In 1998, the Central Area subsurface drains had a minimum SAR value of 5.1 (DPS 1367) and a maximum value of 35.5 (BVS 8003) with a geometric mean of 10.2 mg/L. Accordingly, the Southern Area subsurface drains had a minimum SAR value of 6.3 (COC 4126) and a maximum value of 84.0 (LNW 6459) with a combined arithmetic average of 30.4. Sodium concentrations ranged from 451 to 3,490 mg/L and 508 to 9,050 mg/L for both Central and Southern Areas, respectively.

Boron, an essential mineral for plant growth, can be toxic if excessive levels in irrigation water are applied to plants. Boron toxicity levels are dependent upon climate, soil, and crop variety. Tree and vine crops are the most sensitive (0.5-1.0 mg/L), whereas cotton and asparagus the most tolerant (6.0-15.0 mg/L). The Central Area recorded a maximum level of 49.0 mg/L (DPS 4616) with a combined arithmetic average of 13.8 mg/L. Boron in the Southern Area drains were greater with a maximum concentration of 60.3 mg/L (LNW 5454) and a combined average of 18.2 mg/L. Boron for both surface drains averaged 4.3 mg/L with a maximum level of 8.8 mg/L (DPS 3235).

Concentrations for total hardness, as calcium carbonate, were also lowest in the Central Area with a maximum level of 2,634 mg/L (DPS 4616) and an arithmetic average of 1,877 mg/L. The Southern Area recorded a maximum hardness level of 4,350 mg/L (SFD 2727) and a combined arithmetic average of 1,931 mg/L. In evaluating hardness, warm water levels greater than 300 mg/L can cause scaling in irrigation and drainage pipes. Concentrations greater than 300 mg/L were accounted for in all drains, excluding the surface drain CTL 4504, which recorded a maximum level of 262 mg/L.

In the past effluent at the two surface stations (CTL 4504 and DPS 3235) have had sodium, sulfate, and chloride as their principal mineral constituents. Since surface drains contain a mixture of tail water, reused drain water, and added runoff, the mineral levels are lower than subsurface drainage water. Mineral constituents for the Central and Southern Area drains are listed in Tables 7 and 8, respectively. Potassium, alkalinity, sulfate, and chloride were last sampled in 1992, therefore, no results are listed.

### Pesticides

Extensive sampling and analyses by federal and State scientists from 1984 to 1989 have shown that pesticides are rarely detected in valley subsurface water. As a result, the drainage-monitoring program did not include testing for pesticides in 1998.

### Nutrients

The 1998 drainage-monitoring program did not sample subsurface drains for nutrients. In the past, nutrient data was analyzed for correlation of nutrient values versus the time of year when sampled. This relationship was difficult to evaluate due to:

1. Over-irrigation, which leads to increased leaching of salts from soils.
2. Variable commercial fertilizer application rates.
3. Yearly sample value fluctuations.
4. Variable soil types.

**TABLE 7**  
**MINERAL ANALYSES OF CENTRAL AREA DRAINS**  
**1998**

Station	Date Time	Temp.	Field Laboratory		Mineral Constituents mg/L meq/L				Mineral Constituents (mg/L)			SAR
			°C	pH	EC (µS/cm)	Ca	Mg	Na	NO3	B	TDS Sum	

**BVS 6016**

01/11/1998	16	7.2	6,171	452	152	1090	273.0	6.6	5,220	1,750	11.3
1615	61		6,560	22.55	12.50	47.39	4.40		-		
03/11/1998				452	152	1090	61.6	6.6	5,220		11.3
1200			6,560	22.55	12.50	47.39	0.99		-		
05/20/1998	17	7.4	6,726	510	174	1020	59.3	6.5	5,100		10.0
1310	63		6,690	25.45	14.31	44.35	0.96		-		
09/09/1998	21	7.2	5,098	351	131	706	36.0	4.9	3,940	1,416	8.2
1315	70		5,030	17.51	10.77	30.70	0.58		-		
11/10/1998	20	7.3	8,547	502	194	1370	64.0	10.1	7,090	2,053	13.2
1445	68		8,580	25.05	15.95	59.57	1.03		-		

**BVS 8003**

03/11/1998	16	7.5	7,381	329	192	1530	35.0	16.0	6,510	1,610	16.6
1645	61		7,710	16.42	15.79	66.52	0.56		-		
05/20/1998	17	7.4	9,558	378	239	1850	15.2	20.0	8,000		18.3
1340	63		9,440	18.86	19.65	80.43	0.25		-		
09/09/1998	21	7.3	10,476	363	225	3490	19.0	19.9	8,080	1,833	35.5
1330	70		9,460	18.11	18.50	151.7	0.31		-		

**CTL 4504**

03/11/1998	15	8.1	1,141	62	26	138	6.9	1.5	706	262	3.7
1230	59		1,170	3.09	2.14	6.00	0.11		-		
05/20/1998	18	7.6	260	16	6	24.9	0.2	0.4	150		1.4
910	64		264	0.78	0.46	1.08	0.00		-		
09/09/1998	24	8.1	291	16	7	39	0.7	0.5	168	69	2.0
930	75		291	0.80	0.58	1.70	0.01		-		
11/10/1998	13	7.8	299	17	7	29.83	1.2	0.2	161	73	1.5
1215	55		272	0.86	0.61	1.30	0.02		-		

**TABLE 7**  
**MINERAL ANALYSES OF CENTRAL AREA DRAINS**  
**1998 (continued)**

Station	Date Time	Temp. °C °F	Field Laboratory		Mineral Constituents mg/L meq/L				Mineral Constituents (mg/L)			SAR
			pH	EC (µS/cm)	Ca	Mg	Na	NO3	B	TDS Sum	TH	
<b>DPS 1367</b>												
01/13/1998	17	7.3	5,393	639	28	561	217.0	4.9	4,160	2,120	5.9	
1145	63		5,460	31.89	2.30	24.39	3.50		-			
03/11/1998	17	7.2	5,452	586	123	541	248.0	4.4	4,210	1,970	5.3	
1515	63		5,500	29.24	10.12	23.52	4.00		-			
05/20/1998	18	7.3	5,508	642	143	569	54.5	4.8	4,350		5.3	
1205	64		5,700	32.04	11.76	24.74	0.88		-			
09/09/1998	20	7.2	6,438	589	133	575	56.0	5.1	4,300	2,019	5.6	
1200	68		5,670	29.39	10.94	25.00	0.90		-			
11/10/1998	19	7.3	5,560	582	129	525	53.0	4.7	4,410	1,985	5.1	
1330	66		5,590	29.04	10.61	22.83	0.85		-			
<b>DPS 2535</b>												
05/20/1998	17	7.3	8,165	445	177	1500	22.1	18.1	6,380		15.2	
1050	63		8,400	22.21	14.56	65.22	0.36		-			
<b>DPS 3235</b>												
03/11/1998	17	8.2	4,944	355	98	726	36.3	7.6	3,600	1,290	8.8	
1345	63		4,860	17.71	8.06	31.57	0.58		-			
05/20/1998	17	8.3	5,522	416	116	866	41.4	8.8	4,080		9.7	
1005	63		5,610	20.76	9.54	37.65	0.67		-			
09/09/1998	22	8.2	4,993	371	99	698	26.0	7.8	3,790	1,334	8.3	
1045	72		4,970	18.51	8.14	30.35	0.42		-			
11/10/1998	12	8.3	5,307	433	105	666	28.0	7.6	4,140	1,514	7.5	
1300	54		5,300	21.61	8.63	28.96	0.45		-			
<b>DPS 3465</b>												
03/11/1998	16	7.2	8,470	564	206	1280	86.0	15.0	6,390	2,260	11.7	
1445	61		8,480	28.14	16.94	55.65	1.39		-			
05/20/1998	18	7.2	9,315	602	238	1580	22.1	17.7	7,170		13.8	
1125	64		9,700	30.04	19.57	68.70	0.36		-			
09/09/1998	21	6.7	7,776	494	182	1050	17.0	12.9	4,870	1,983	10.3	
1130	70		7,190	24.65	14.97	45.65	0.27		-			

**TABLE 7**  
**MINERAL ANALYSES OF CENTRAL AREA DRAINS**  
**1998 (continued)**

Station	Date Time	Temp.	Field Laboratory		Mineral Constituents mg/L meq/L				Mineral Constituents (mg/L)			SAR
			°C °F	pH	EC (µS/cm)	Ca	Mg	Na	NO3	B	TDS Sum	
<b>DPS 4616</b>												
03/11/1998	14	7.5	11,938	443	354	2380	52.0	45.0	10,100	2,560	20.5	
1145	57		11,900	22.11	29.11	103.4	0.84		-			
05/20/1998	16	7.4	12,221	449	409	2410	12.3	49.0	10,300		19.8	
830	61		12,300	22.41	33.63	104.7	0.20		-			
11/10/1998	16	7.4	11,760	438	374	2110	12.0	49.0	9,880	2,634	17.9	
1130	61		11,590	21.86	30.76	91.74	0.19		-			
<b>FBH 2016</b>												
05/20/1998	18	7.6	9,315	470	295	1770	21.5	16.0	8,260		15.8	
1445	64		9,520	23.45	24.26	76.96	0.35		-			
09/09/1998	20	7.4	6,660	416	161	834	13.0	8.0	4,890	1,702	8.8	
1415	68		5,800	20.76	13.24	36.26	0.21		-			
<b>FBH 8061</b>												
03/11/1998	15	7.4	4,340	324	123	618	38.0	6.2	3,530	1,320	7.4	
1715	59		4,380	16.17	10.12	26.87	0.61		-			
<b>HMH 7516</b>												
01/13/1998	18	7.3	3,659	344	62	495	170.0	7.0	2,690	1,110	6.5	
1215	64		3,800	17.17	5.10	21.52	2.74		-			
03/11/1998	17		4,508	407	77	542	230.0	7.0	3,260	1,330	6.5	
1545	63		4,540	20.31	6.33	23.57	3.71		-			
05/20/1998	18	7.3	4,174	372	74	584	45.9	7.0	3,050		7.2	
1235	64		4,290	18.56	6.09	25.39	0.74		-			
09/09/1998	20	7.1	4,940	426	82	622	54.0	8.2	3,690	1,402	7.2	
1230	68		4,840	21.26	6.74	27.04	0.87		-			
11/10/1998	12	7.2	3,684	265	56	451	38.0	6.8	2,604	2,610	6.6	
1415	54		3,850	13.22	4.61	19.61	0.61		-			

TABLE 8  
MINERAL ANALYSES OF SOUTHERN AREA DRAINS  
1998

Station	Date Time	Temp. °C °F	Field Laboratory		Mineral Constituents mg/L meq/L				Mineral Constituents (mg/L)			SAR
			pH	EC (μS/cm)	Ca	Mg	Na	NO3	B	TDS Sum	TH	

**CNR 0801**

01/13/1998	19	7.1	13,334	414	356	2720	58.0	28.0	11,300	2,500	23.7
1415	66			20.66	29.28	118.2	0.94		-		
03/09/1998		7.2	11,500	360	286	2210	50.2	21.0	9,300		21.1
1600			10,600	17.96	23.52	96.09	0.81		-		
05/04/1998	19	7.1	10,170	385	355	1840	37.8	20.0	8,640		16.3
1215	66		9,800	19.21	29.19	80.00	0.61		-		
07/06/1998	21	7.2	12,150	380	331	2560	53.0	27.7	10,800		23.2
1315	70		11,900	18.96	27.22	111.3	0.85		-		
09/08/1998	23	7.1	11,440	362	299	2340	54.0	24.9	10,100	2,136	22.0
1400	73		11,300	18.06	24.59	101.7	0.87		-		

**COC 4126**

03/09/1998		7.5	6,325	580	160	668	106.8	2.6	4,820		6.3
1530			5,420	28.94	13.16	29.04	1.72		-		
05/04/1998	19	7.1	7,062	604	172	697	98.7	2.9	4,930		6.4
1145	66		5,530	30.14	14.14	30.30	1.59		-		
09/08/1998	25	7.3	5,500	549	144	640	81.0	2.9	4,830	1,964	6.3
1330	77		5,300	27.40	11.84	27.83	1.31		-		
11/09/1998	19	7.3	5,509	449	137	1120	19.0	4.8	6,140	1,680	11.9
1300	66		6,940	22.41	11.27	48.70	0.31		-		

**COC 5329**

01/13/1998	19	7.5	7,797	544	150	1030	51.0	4.5	5,640	1,980	10.1
1300	66			27.15	12.34	44.78	0.82		-		
03/09/1998		7.2	8,338	581	184	1400	28.3	7.0	6,740		13.0
1500			7,960	28.99	15.13	60.87	0.46		-		
05/04/1998	19	6.9	9,040	605	187	1360	48.8	6.7	6,670		12.4
1100	66		7,940	30.19	15.38	59.13	0.79		-		
07/06/1998	22	6.9	8,215	588	187	1420	14.0	8.3	7,160		13.1
1215	72		8,250	29.34	15.38	61.74	0.23		-		
09/08/1998		6.8	7,038	538	156	1060	13.0	6.1	6,080	1,986	10.4
1300			6,860	26.85	12.83	46.09	0.21		-		

**TABLE 8**  
**MINERAL ANALYSES OF SOUTHERN AREA DRAINS**  
**1998 (continued)**

Station	Date Time	Temp.	Field Laboratory		Mineral Constituents mg/L meq/L				Mineral Constituents (mg/L)			SAR
			°C °F	pH	EC (μS/cm)	Ca	Mg	Na	NO <sub>3</sub>	B	TDS Sum	
<b>ERR 7525</b>												
09/08/1998 845	21 70	7.1	5,195 5,370	150 7.49	84 6.91	1060 46.09	11.0 0.18		2.5	4,010 -	721	17.2
11/10/1998 945	18 64	7.0	4,514 5,380	137 6.84	72 5.92	973 42.30	5.1 0.08		2.5	4,030 -	639	16.8
<b>ERR 8429</b>												
01/13/1998 1000	19 66	7.3	9,153 5.59	112 7.32	89 90.00	2070 1.02	63.0 1.02		3.0	6,360 -	646	35.4
03/10/1998 1000		7.3	10,638 10,000	122 6.09	105 8.63	2270 98.70	15.5 0.25		3.7	7,410 -		36.4
05/20/1998 1330	18 64	7.5	8,050 7,390	101 5.04	81 6.66	1720 74.78	17.5 0.28		2.7	5,260 -		30.9
07/07/1998 845	22 72	7.3	5,935 6,130	125 6.24	68 5.60	1310 56.96	22.0 0.35		3.0	4,460 -		23.4
09/09/1998 900	22 72	7.3	9,275 9,160	132 6.59	93 7.65	2000 86.96	29.0 0.47		3.8	6,900 -	713	32.6
11/10/1998 1015	18 64	7.2	8,050 8,660	118 5.89	81 6.66	1770 76.96	25.0 0.40		3.1	6,590 -	628	30.7
<b>ERR 8641</b>												
01/13/1998 1015	19 66	7.1	4,238 6.79	136 6.17	75 37.22	856 0.03	2.1 0.03		1.4	3,230 -	649	14.6
05/20/1998 1415	17 63	7.1	16,284 15,000	364 18.16	330 27.14	3570 155.2	1.7 0.03		3.7	12,600 -		32.6
09/09/1998 915	20 68	7.3	14,319 14,100	263 13.12	299 24.59	2980 129.5	1.5 0.02		3.5	11,800 -	1,888	29.9
<b>GSY 0855</b>												
11/10/1998 1045	18 64	7.5	12,362 14,600	455 22.70	358 29.44	3080 133.9	4.5 0.07		4.1	13,540 -	2,600	26.2

**TABLE 8**  
**MINERAL ANALYSES OF SOUTHERN AREA DRAINS**  
**1998 (continued)**

Station	Date Time	Temp. °C °F	Field Laboratory		Mineral Constituents mg/L meq/L				Mineral Constituents (mg/L)			SAR
			pH	EC ( $\mu$ S/cm)	Ca	Mg	Na	NO <sub>3</sub>	B	TDS Sum	TH	
<b>LNW 5454</b>												
01/13/1998	19	7.1	25,990	542	295	6090	166.0	41.0	20,000	2,570	52.3	
1100	66				27.05	24.26	264.7	2.68		-		
05/20/1998	18	7.3	25,588	538	278	6330	39.3	50.9	26,000		55.2	
1030	64		25,000	26.85	22.86	275.2	0.63		-			
09/08/1998	25	7.3	18,000	449	138	4150	34.0	60.3	14,800	1,690	43.9	
1130	77		17,700	22.41	11.35	180.4	0.55		-			
11/09/1998	19	7.6	20,622	446	189	4470	32.0	42.9	16,580	1,892	44.7	
	1115	66		19,800	22.26	15.54	194.3	0.52		-		
<b>LNW 5467</b>												
01/13/1998	19	7.3	14,408	545	174	2800	316.0	18.0	10,700	2,080	26.7	
1130	66				27.20	14.31	121.7	5.10		-		
03/09/1998		6.9	10,350	579	115	2010	65.7	12.9	8,140		20.0	
	1300		10,400	28.89	9.46	87.39	1.06		-			
05/20/1998	18	7.5	16,100	584	211	3280	75.1	22.7	11,600		29.6	
1000	64		15,100	29.14	17.35	142.6	1.21		-			
09/08/1998	23	6.9	13,372	1,05	342	2680	65.0	36.9	10,100	4,031	18.4	
1100	73		13,100	52.40	28.13	116.5	1.05		-			
11/09/1998	19	7.5	12,430	532	158	2090	62.0	15.8	9,840	1,979	20.4	
	1045	66		12,300	26.55	12.99	90.87	1.00		-		
<b>LNW 6459</b>												
03/09/1998		7.3	35,560	522	278	8660	27.4	41.1	26,200		76.2	
	1230		34,300	26.05	22.86	376.5	0.44		-			
07/06/1998	21	7.3	35,532	450	261	9050	37.0	46.2	25,800		84.0	
	945	70	35,300	22.46	21.46	393.4	0.60		-			
09/08/1998	23	7.2	24,180	467	187	6300	28.0	38.1	19,300	1,937	62.3	
	1015	73		24,000	23.30	15.38	273.9	0.45		-		

**TABLE 8**  
**MINERAL ANALYSES OF SOUTHERN AREA DRAINS**  
**1998 (continued)**

Station	Date Time	Temp. °C °F	Field Laboratory		Mineral Constituents mg/L meq/L				Mineral Constituents (mg/L)			SAR
			pH	EC (µS/cm)	Ca	Mg	Na	NO <sub>3</sub>	B	TDS Sum	TH	
<b>LNW 6467</b>												
05/20/1998 945	18 64	7.3	27,370 26,600	584 29.14	362 29.77	6800 295.6	65.3 1.05	44.0	23,200	-	54.5	
07/06/1998 1015	21 70	7.2	24,570 24,100	551 27.50	298 24.51	5850 254.3	63.0 1.02	42.0	19,000	-	49.9	
09/08/1998 1045	23 73	7.1	25,220 24,800	531 26.50	316 25.99	6080 264.3	60.0 0.97	43.2	20,200 2,628	-	51.6	
<b>SFD 2727</b>												
01/13/1998 1130	19 66	7.1	15,820 21.21	425 65.71	799 103.4	2380 2.32	144.0 -	4.2	6,340 4,350	-	15.7	
05/20/1998 1500	18 64	6.9	9,775 9,410	296 14.77	606 49.84	1650 71.74	13.3 0.21	2.8	8,900	-	12.6	
07/07/1998 1030	22 72	7.3	8,750 9,610	257 12.82	539 44.33	1642 71.39	15.0 0.24	3.0	9,080	-	13.4	
09/09/1998 1015	22 72	6.8	3,684 3,770	159 7.93	170 13.98	508 22.09	7.1 0.11	1.2	3,030 1,097	-	6.7	
<b>STC 5436</b>												
07/01/1998 745	20 68	7.5	11,378 11,900	90 4.51	34 2.75	2980 129.5	18.0 0.29	10.3	8,530	-	68.0	
09/09/1998 1200	21 70	7.3	7,830 8,100	132 6.59	47 3.87	1660 72.17	21.0 0.34	5.5	5,600 -	523	31.6	
<b>VGD 3906</b>												
05/20/1998 845	18 64	7.3	28,580 28,100	409 20.41	777 63.90	8170 355.2	7.8 0.13	36.0	28,600	-	54.7	
07/06/1998 815	19 66	7.3	26,272 26,200	354 17.66	640 52.63	7200 313.0	11.0 0.18	33.9	21,300	-	52.8	
09/08/1998 900	21 70	7.3	25,650 25,000	424 21.16	658 54.11	6600 286.9	9.8 0.16	34.9	24,900 -	3,769	46.8	
<b>VGD 4406</b>												
09/08/1998 830	21 70	7.2	19,710 18,700	421 21.01	386 31.74	4820 209.5	16.0 0.26	33.1	18,500 -	2,641	40.8	

**TABLE 8**  
**MINERAL ANALYSES OF SOUTHERN AREA DRAINS**  
**1998 (continued)**

Station	Date Time	Temp.	Field		Mineral Constituents				Mineral Constituents			SAR
			Laboratory		mg/L meq/L				(mg/L)			
		°C °F	pH	EC (µS/cm)	Ca	Mg	Na	NO <sub>3</sub>	B	TDS Sum	TH	

**VGD 5412**

03/09/1998		7.3	8,338	347	196	2900	10.8	19.9	10,700			30.9
1000			12,100	17.32	16.12	126.0	0.17		-			
05/20/1998	17	7.3	14,750	376	257	3580	12.2	24.0	11,000			34.9
730	63		14,100	18.76	21.13	155.6	0.20		-			
07/06/1998	19	7.3	13,842	337	265	3390	15.0	21.6	12,700			33.6
745	66		13,800	16.82	21.79	147.3	0.24		-			
09/08/1998	21	7.3	15,120	357	303	3520	12.0	23.6	13,700	2,140		33.1
815	70		15,100	17.81	24.92	153.0	0.19		-			

### Trace Elements

Trace elements occur naturally in rock and soil. Aluminum, barium, cadmium, cobalt, copper, iron, lead, mercury, silver, and zinc historically have been very low or undetectable in drainage water. Consequently, they have not been sampled since 1987. Selenium was the only trace element sampled for in 1998. A summary of selenium concentrations detected in the Central and Southern Area drains is listed in Table 9. The 1998 selenium levels are compared to laboratory EC, and field pH in Tables 10 and 11 for the Central and Southern stations, respectively.

TABLE 9  
SUMMARY OF SELENIUM DETECTED  
1998  
(milligrams per Liter)

Area	Minimum	Maximum	Arithmetic Average	Geometric Mean
Central Surface Drains	0.001	0.124	0.043	0.012
Central Subsurface Drains	0.016	0.173	0.080	0.059
Southern Subsurface Drains	0.001	0.780	0.091	0.019

### Selenium

Selenium is a naturally occurring, nonmetallic chemical element that accumulates in drainage water when selenium-enriched salts are leached into the shallow groundwater. Water-quality problems associated with selenium are most likely in areas of the San Joaquin Valley where soils are formed of sediments from marine sedimentary rocks of the Coast Range. The occurrence of Coast Range sediments and the highest selenium concentrations are clearly linked throughout the Valley. Three areas of the western valley (1) the alluvial fans near Panoche and Cantua Creeks in the central western valley, (2) an area west of the town of Lost Hills, and (3) the Buena Vista Lake Bed area have the highest soil selenium concentrations. High concentrations of selenium occur in subsurface drain water from some agricultural lands near, but not necessarily within, all three areas.

Selenium levels for the Central Area subsurface drains ranged from 0.016 to 0.173 mg/L; the Central surface drains ranged from 0.001 to 0.124 mg/L. All Southern Area drains had measurable levels of selenium, varying from 0.001 to 0.78 mg/L. Selenium levels for the Central and Southern Area stations are shown in Figures 4 through 7.

TABLE 10  
 SELENIUM, ELECTRICAL CONDUCTIVITY, and FIELD pH  
 CENTRAL AREA DRAINS  
 1998

Station	Date	Se mg/L	Lab. EC $\mu\text{S}/\text{cm}$	Field pH
BVS 6016	01/11/98	0.106	6,560	7.2
BVS 6016	03/11/98	0.106	6,560	-
BVS 6016	05/20/98	0.102	6,690	7.4
BVS 6016	09/09/98	0.059	5,030	7.2
BVS 6016	11/10/98	0.159	8,580	7.3
BVS 8003	03/11/98	0.093	7,710	7.5
BVS 8003	05/20/98	0.170	9,440	7.4
BVS 8003	09/09/98	0.067	9,460	7.3
CTL 4504*	03/11/98	0.004	1,170	8.1
CTL 4504*	05/20/98	0.001	264	7.6
CTL 4504*	09/09/98	0.001	291	8.1
CTL 4504*	11/10/98	0.002	272	7.8
DPS 1367	01/13/98	0.142	5,460	7.3
DPS 1367	03/11/98	0.152	5,500	7.2
DPS 1367	05/20/98	0.170	5,700	7.3
DPS 1367	09/09/98	0.162	5,670	7.2
DPS 1367	11/10/98	0.164	5,590	7.3
DPS 2535	05/20/98	0.031	8,400	7.3

\* Surface Drain

Station	Date	Se mg/L	Lab. EC $\mu\text{S}/\text{cm}$	Field pH
DPS 3235*	03/11/98	0.085	4,860	8.2
DPS 3235*	05/20/98	0.124	5,610	8.3
DPS 3235*	09/09/98	0.065	4,970	8.2
DPS 3235*	11/10/98	0.064	5,300	8.3
DPS 3465	03/11/98	0.028	8,480	7.2
DPS 3465	05/20/98	0.030	9,700	7.2
DPS 3465	09/09/98	0.018	7,190	6.7
DPS 4616	03/11/98	0.017	11,900	7.5
DPS 4616	05/20/98	0.019	12,300	7.4
DPS 4616	11/10/98	0.016	11,590	7.4
FBH 2016	05/20/98	0.037	9,520	7.6
FBH 2016	09/09/98	0.173	5,800	7.4
FBH 8061	03/11/98	0.038	4,380	7.4
HMH 7516	01/13/98	0.032	3,800	7.3
HMH 7516	03/11/98	0.050	4,540	-
HMH 7516	05/20/98	0.041	4,290	7.3
HMH 7516	09/09/98	0.045	4,840	7.1
HMH 7516	11/10/98	0.025	3,850	7.2

TABLE 11  
 SELENIUM, ELECTRICAL CONDUCTIVITY, and FIELD pH  
 SOUTHERN AREA SUBSURFACE DRAINS  
 1998

Station	Date	Se mg/L	Lab. EC μS/cm	Field pH
CNR 0801	01/13/98	0.008	13,334	7.1
CNR 0801	03/09/98	0.031	10,600	7.2
CNR 0801	05/04/98	0.033	9,800	7.1
CNR 0801	07/06/98	0.032	11,900	7.2
CNR 0801	09/08/98	0.027	11,300	7.1
COC 4126	03/09/98	0.030	5,420	7.5
COC 4126	05/04/98	0.032	5,530	7.1
COC 4126	09/08/98	0.028	5,300	7.3
COC 4126	11/09/98	0.102	6,940	7.3
COC 5329	01/13/98	0.095	7,797	7.5
COC 5329	03/09/98	0.318	7,960	7.2
COC 5329	05/04/98	0.402	7,940	6.9
COC 5329	07/06/98	0.256	8,250	6.9
COC 5329	09/08/98	0.252	6,860	6.8
ERR 7525	09/09/98	0.007	5,370	7.1
ERR 7525	11/10/98	0.007	5,380	7.0
ERR 8429	01/13/98	0.005	9,153	7.3
ERR 8429	03/10/98	0.001	10,000	7.3
ERR 8429	05/20/98	0.005	7,390	7.5
ERR 8429	07/07/98	0.004	6,130	7.3
ERR 8429	09/09/98	0.005	9,160	7.3
ERR 8429	11/10/98	0.005	8,660	7.2
ERR 8641	01/13/98	0.001	4,238	7.1
ERR 8641	05/20/98	0.010	15,000	7.1
ERR 8641	09/09/98	0.006	14,100	7.3
GSY 0855	11/10/98	0.017	14,600	7.5
LNW 5454	01/13/98	0.236	25,990	7.1
LNW 5454	05/20/98	0.203	25,000	7.3
LNW 5454	09/08/98	0.008	17,700	7.3
LNW 5454	11/09/98	0.108	19,800	7.6

Station	Date	Se mg/L	Lab. EC μS/cm	Field pH
LNW 5467	01/13/98	0.180	14,408	7.3
LNW 5467	03/09/98	0.104	10,400	6.9
LNW 5467	05/20/98	0.206	15,100	7.5
LNW 5467	09/08/98	0.181	13,100	6.9
LNW 5467	11/09/98	0.124	12,300	7.5
LNW 6459	03/09/98	0.085	34,300	7.3
LNW 6459	07/06/98	0.082	35,300	7.3
LNW 6459	09/08/98	0.060	24,000	7.2
LNW 6467	05/20/98	0.620	26,600	7.3
LNW 6467	07/06/98	0.270	24,100	7.2
LNW 6467	09/08/98	0.780	24,800	7.1
SFD 2727	01/13/98	0.007	15,820	7.1
SFD 2727	05/20/98	0.004	9,410	6.9
SFD 2727	07/07/98	0.004	9,610	7.3
SFD 2727	09/09/98	0.002	3,770	6.8
STC 5436	07/01/98	0.001	11,900	7.5
STC 5436	09/09/98	0.001	8,100	7.3
VGD 3906	05/20/98	0.003	28,100	7.3
VGD 3906	07/06/98	0.003	26,200	7.3
VGD 3906	09/08/98	0.003	25,000	7.3
VGD 4406	09/08/98	0.002	18,700	7.2
VGD 5412	03/09/98	0.002	12,100	7.3
VGD 5412	05/20/98	0.002	14,100	7.3
VGD 5412	07/06/98	0.002	13,800	7.3
VGD 5412	09/08/98	0.002	15,100	7.3

## DWR's Future Monitoring Program

Plans are being formulated to modify and redirect activities of DWR's ongoing monitoring program. Additional piezometers will be installed in areas where groundwater level and quality data are lacking. This effort will be focused in the Lost Hills, Buttonwillow and Buena Vista areas. Currently, a plan is being developed to replace non-functioning flow accumulator meters on existing sumps and to install flow accumulators on new sumps. This work involves cooperation and participation from water and drainage districts and from willing growers. Protocols to collect data from the various districts are being refined so that data can be obtained and evaluated in a timely manner.

The two databases that store groundwater and sump data are being refined. Also, preparations are being made to produce a 2001 Electrical Conductivity Map. In addition, plans are being made to solicit regulatory agencies for appropriate drainage data that can be included in the annual report. Lastly, water quality sampling will be modified yearly to address specific constituent issues.

*Insert:*

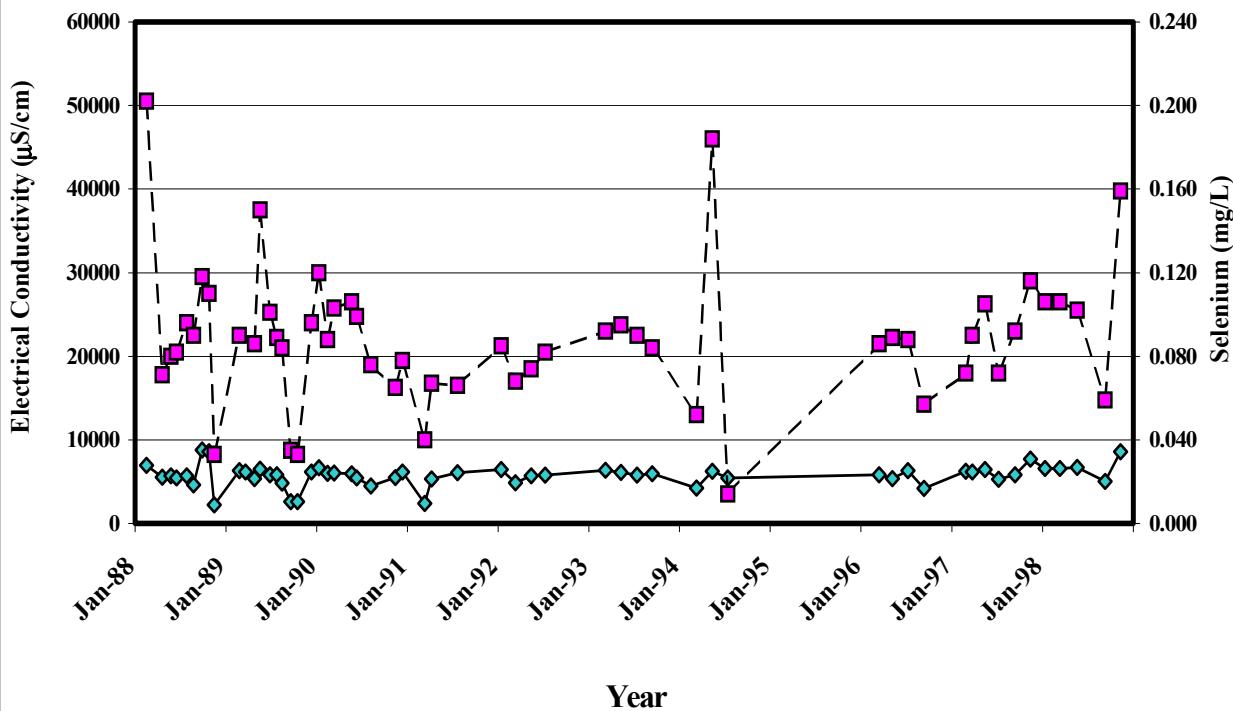
- Figure 4, 1998 Selenium Levels-Central Area Stations (p. 26)
- Figure 5, 1998 Selenium Levels-Southern Area, Lemoore/Corcoran Stations (p.27)
- Figure 6, 1998 Selenium Levels-Southern Area, Lost Hills/Semtropic Stations (p.28).
- Figure 7, 1998 Selenium Levels-Southern Area, Kern Lakebed Stations (p.29).

APPENDIX A  
GRAPHS OF WATER QUALITY IN DRAINAGE SUMPS  
CENTRAL AREA

### Sump BVS 6016

#### Electrical Conductivity and Selenium

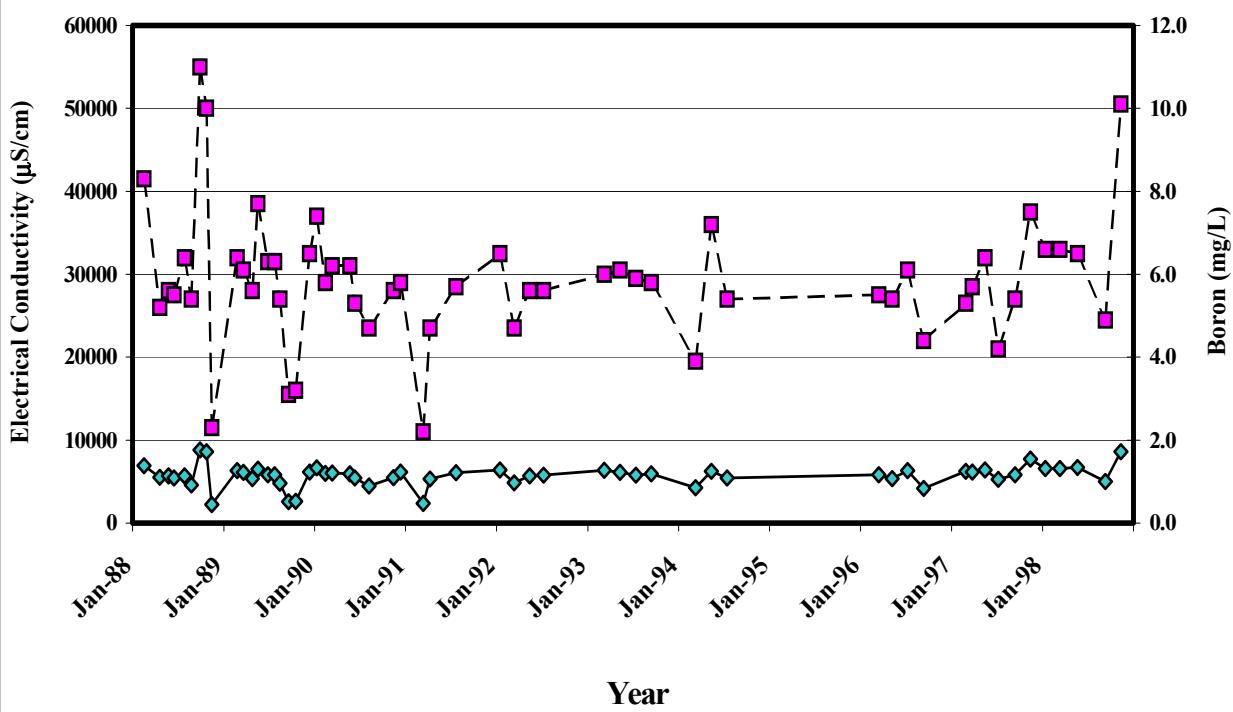
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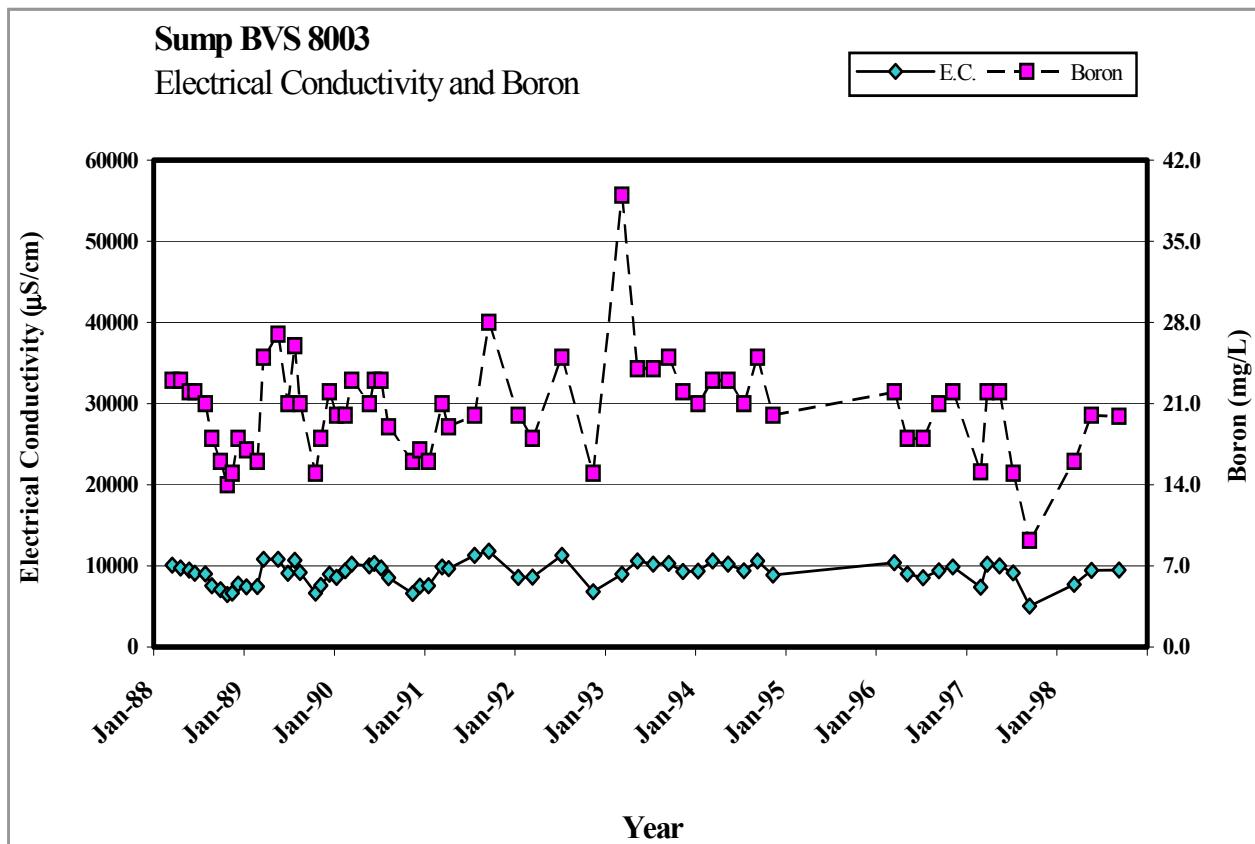
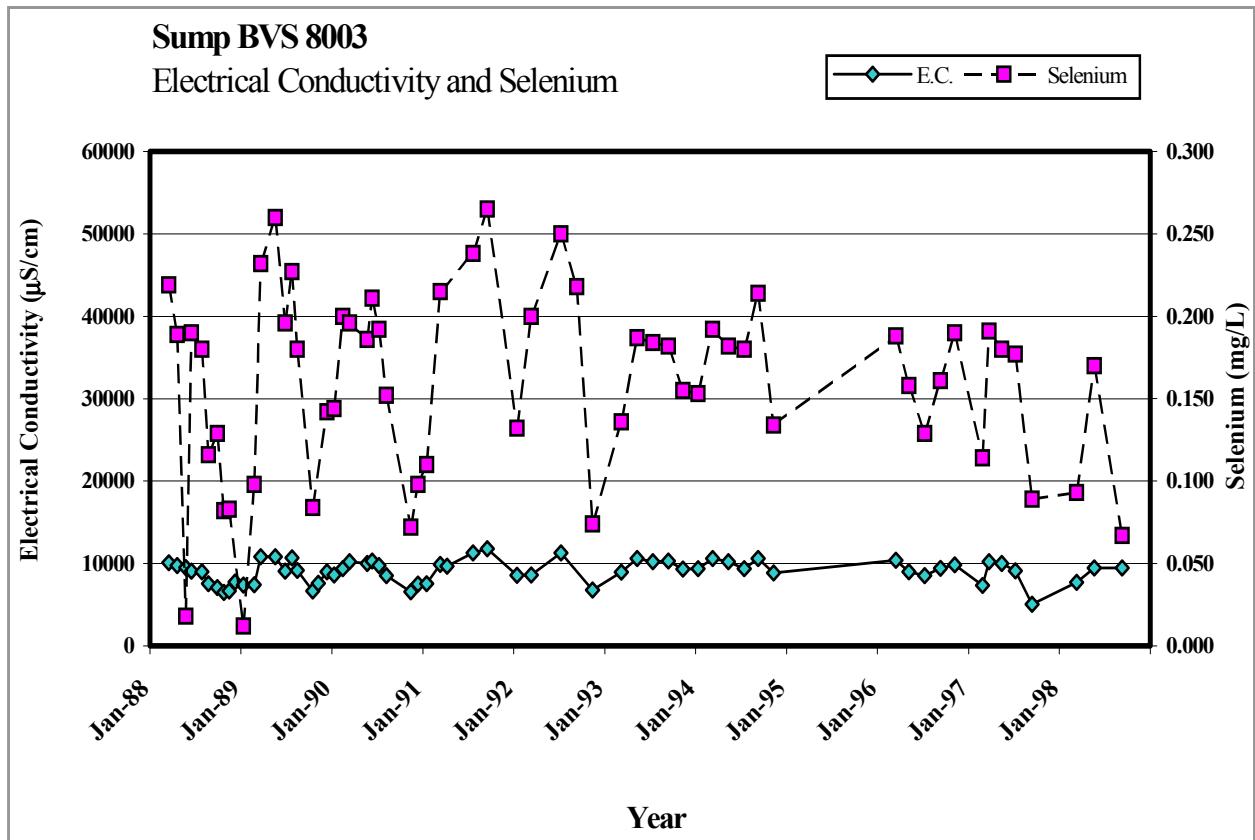


### Sump BVS 6016

#### Electrical Conductivity and Boron

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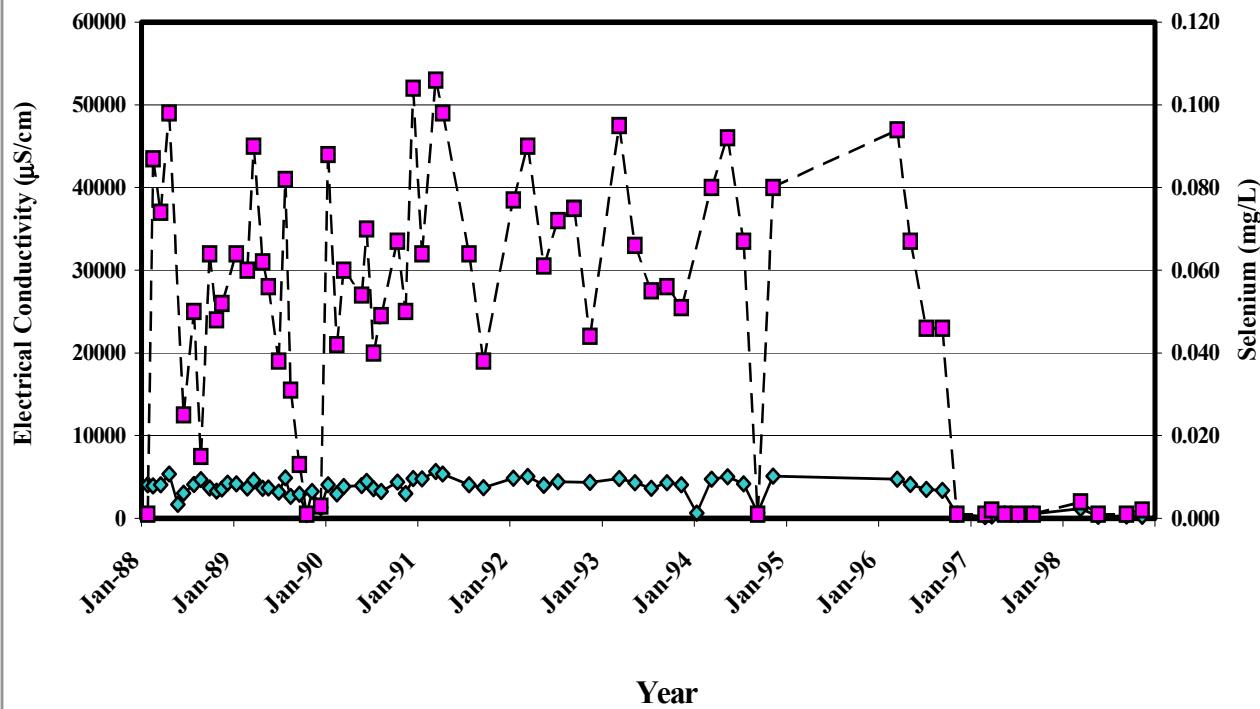




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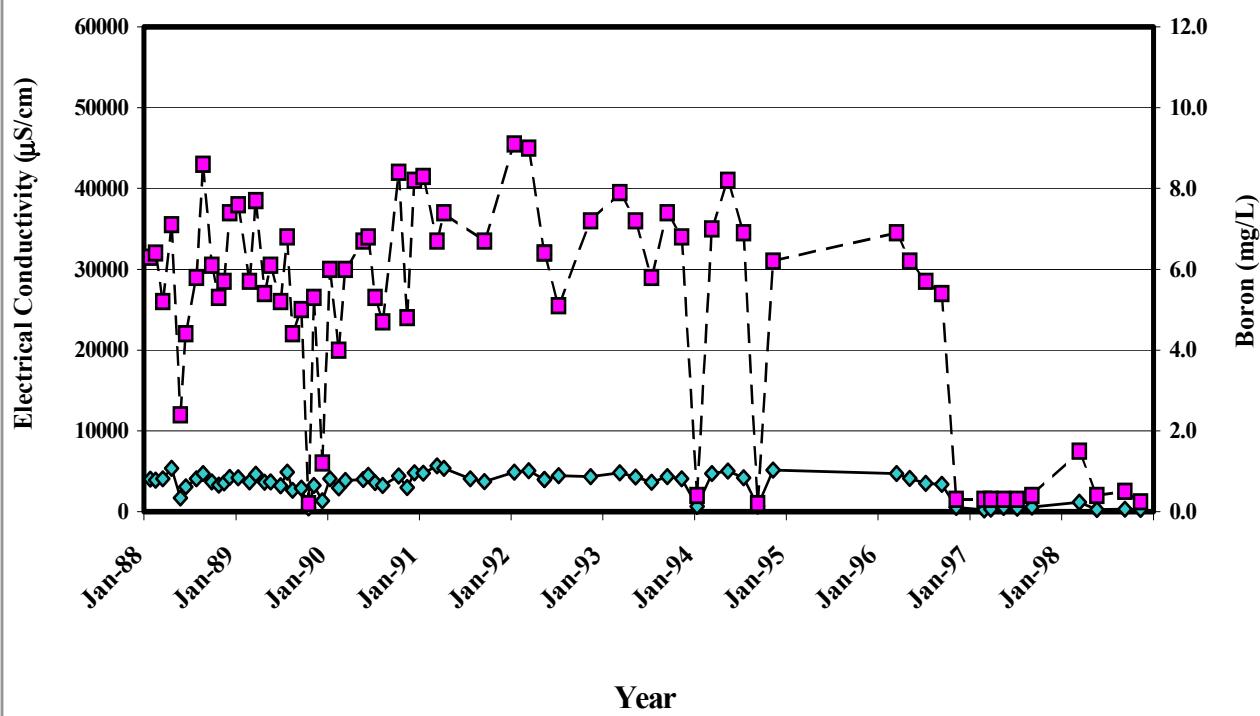
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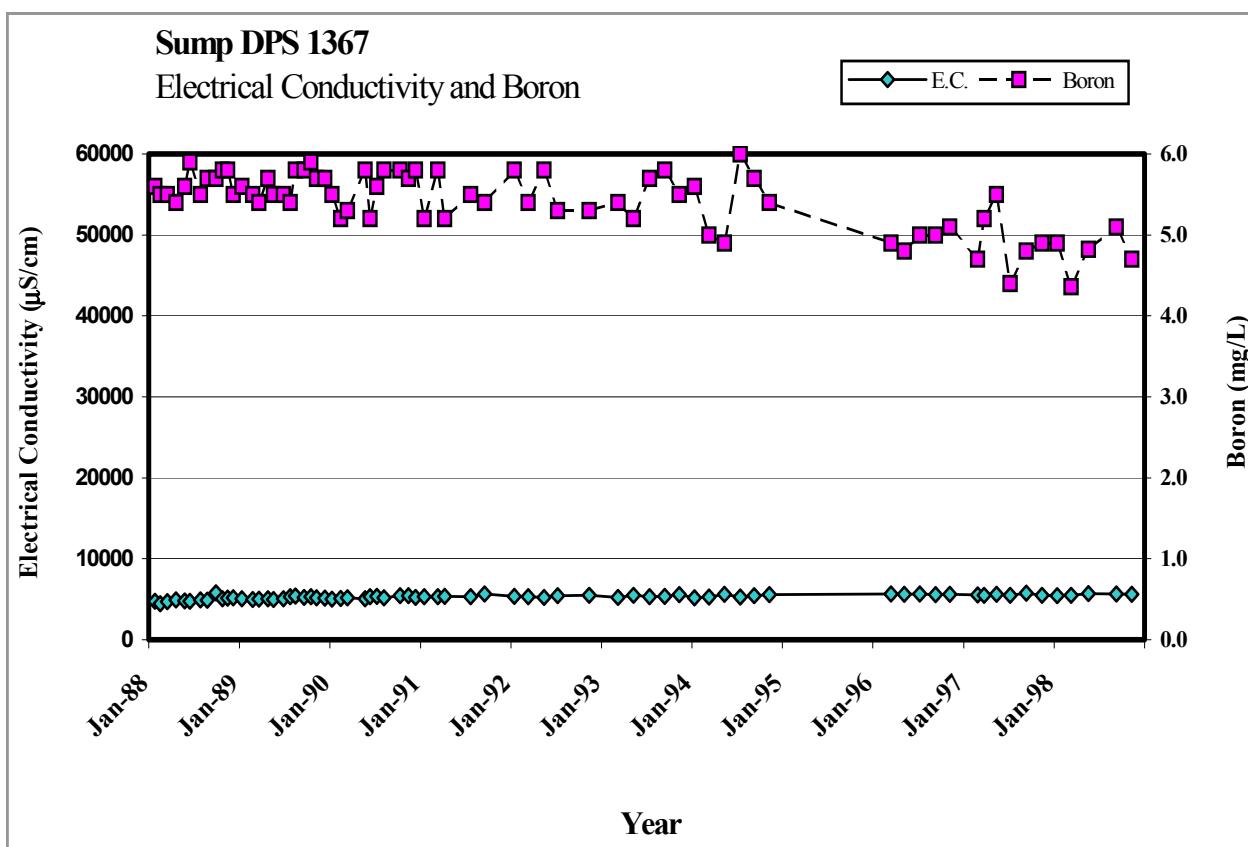
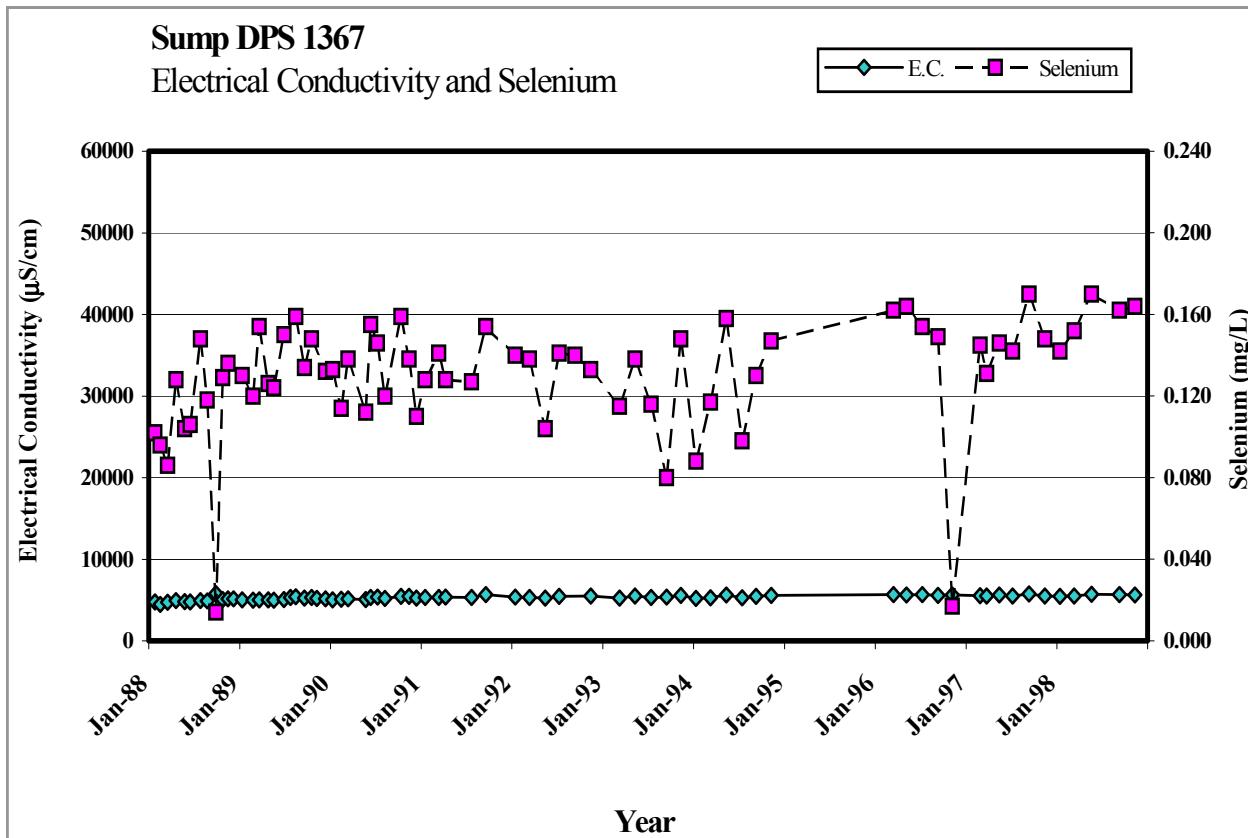


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Electrical Conductivity and Boron

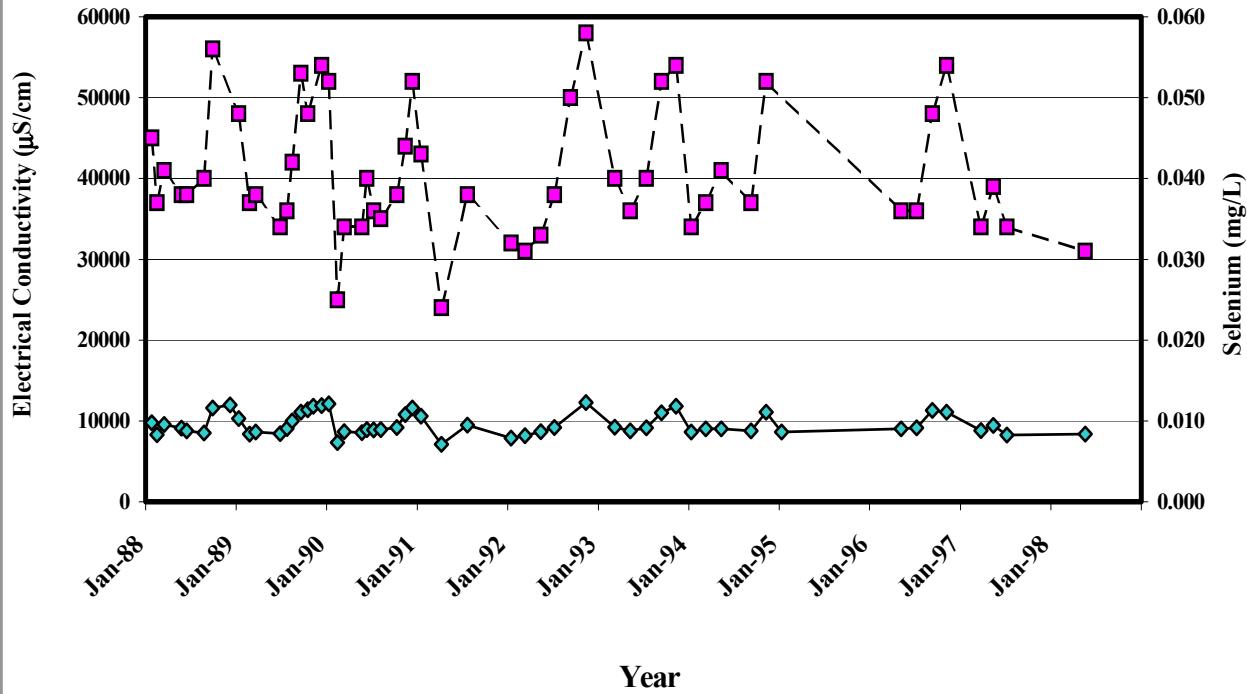
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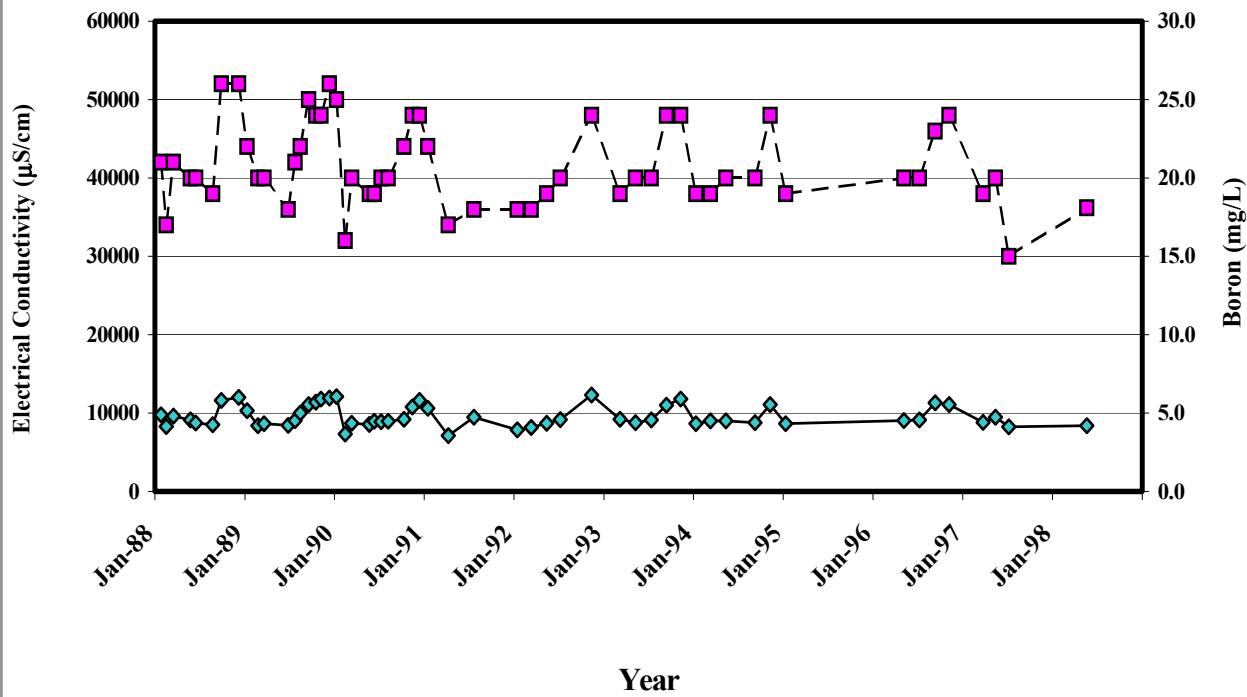
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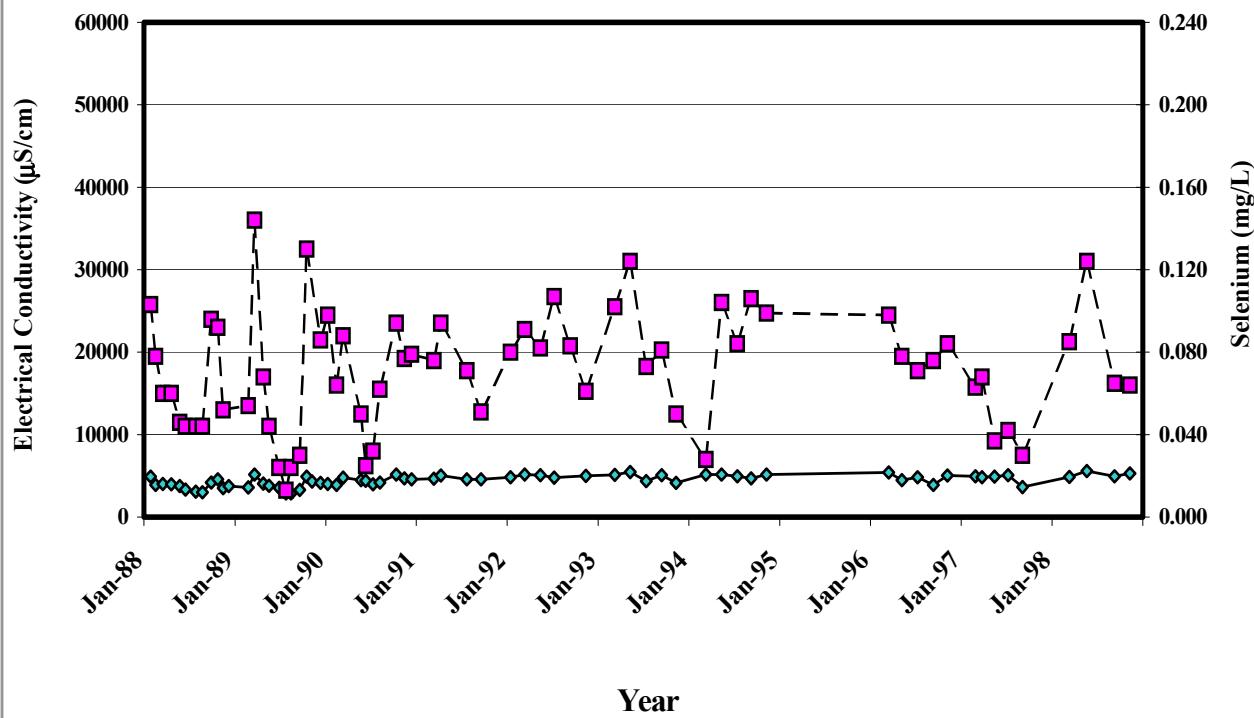
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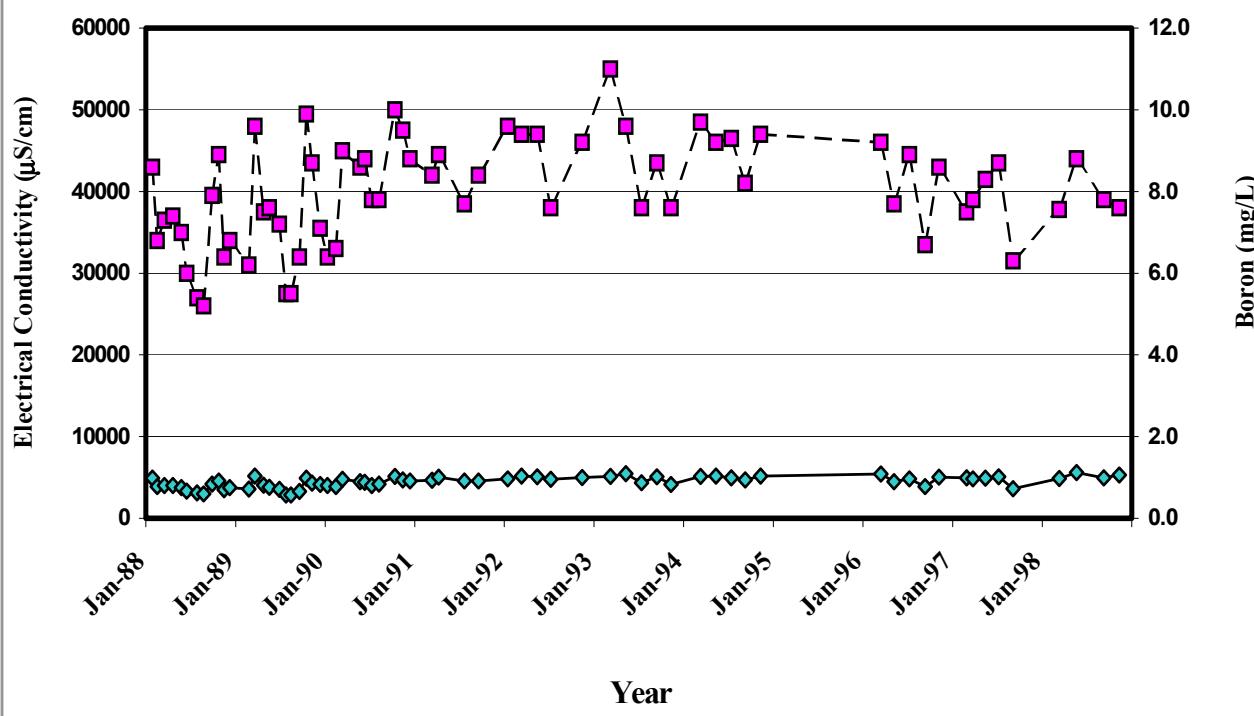
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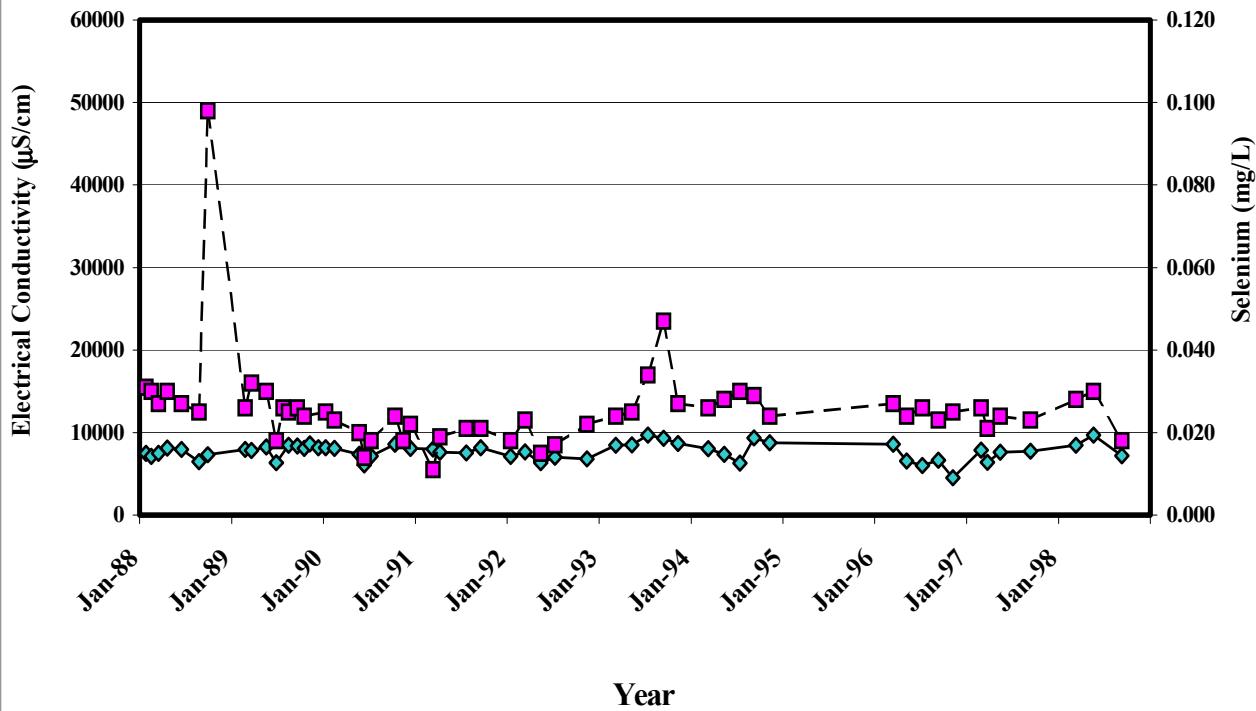
Electrical Conductivity and Boron

—◆— E.C. —■— Boron



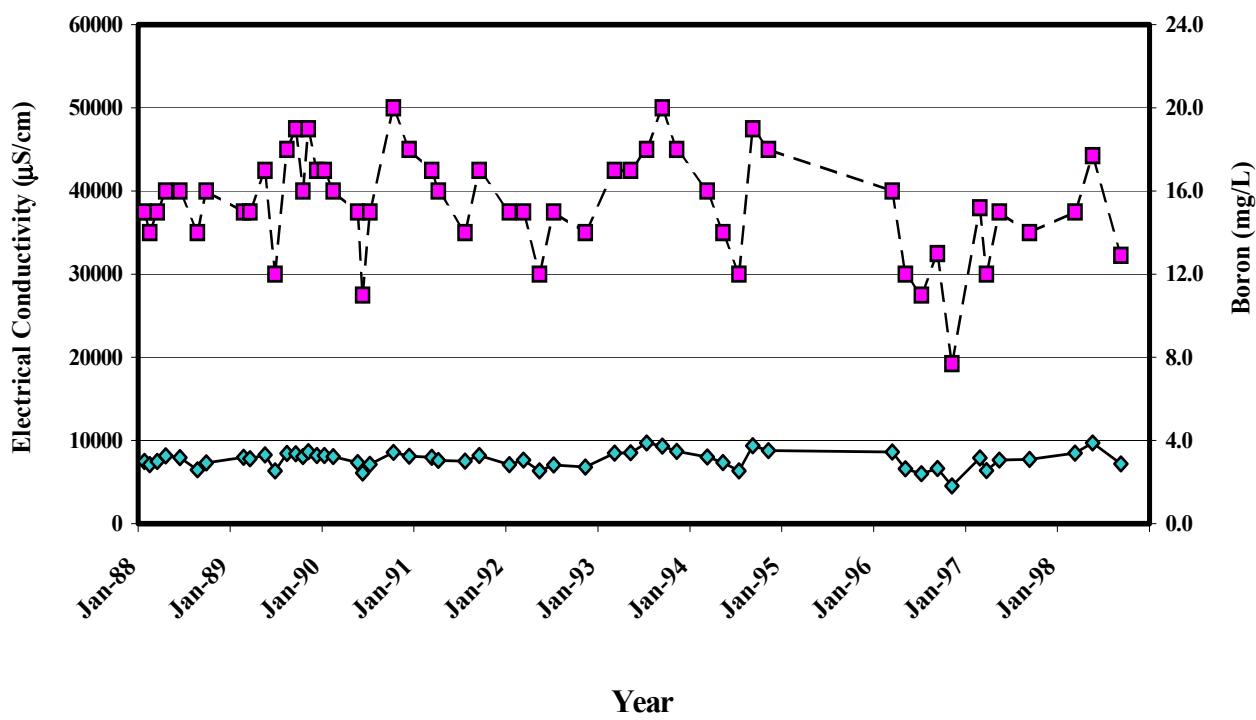
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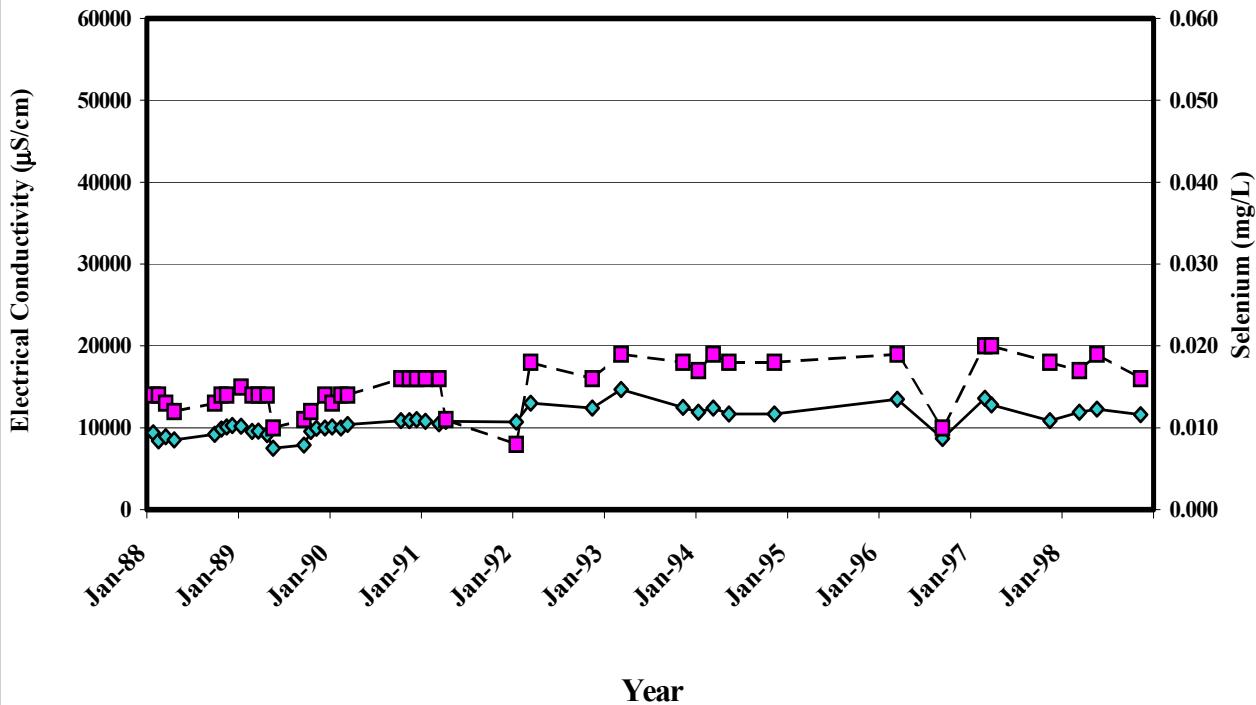
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— E.C. — Boron



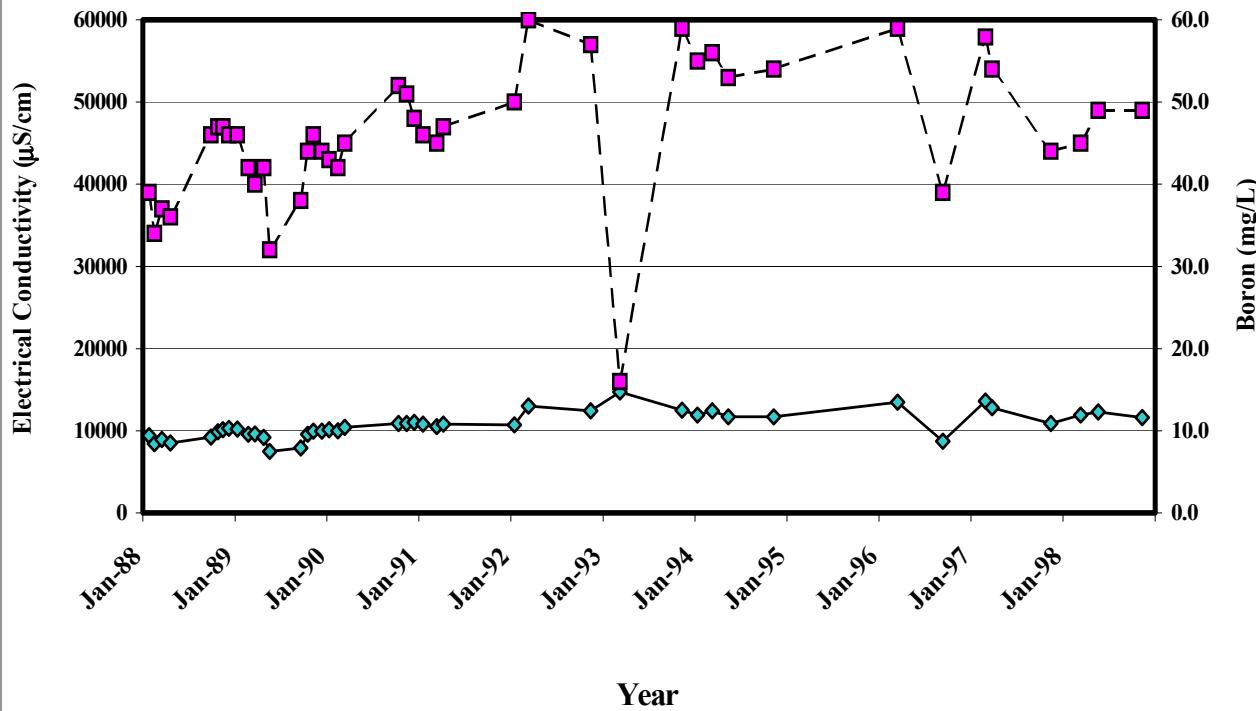
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Electrical Conductivity and Selenium

— E.C. — Selenium



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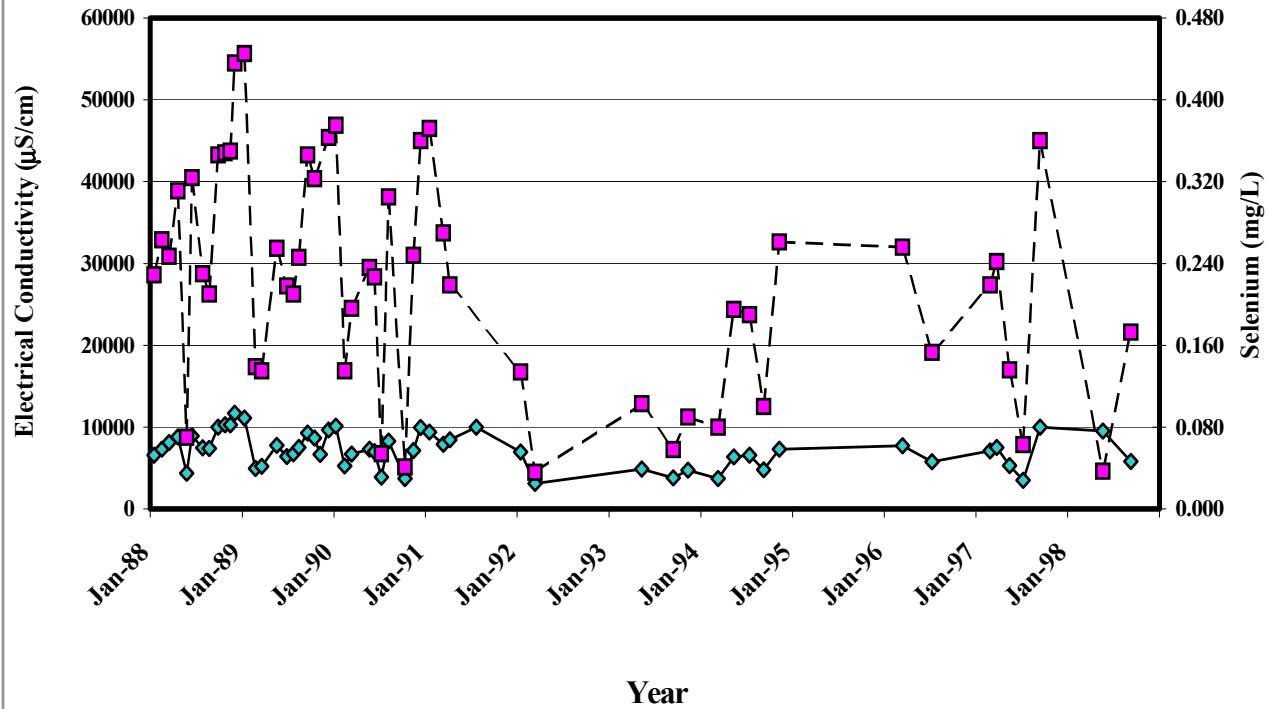
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### Sump FBH 2016

Electrical Conductivity and Selenium

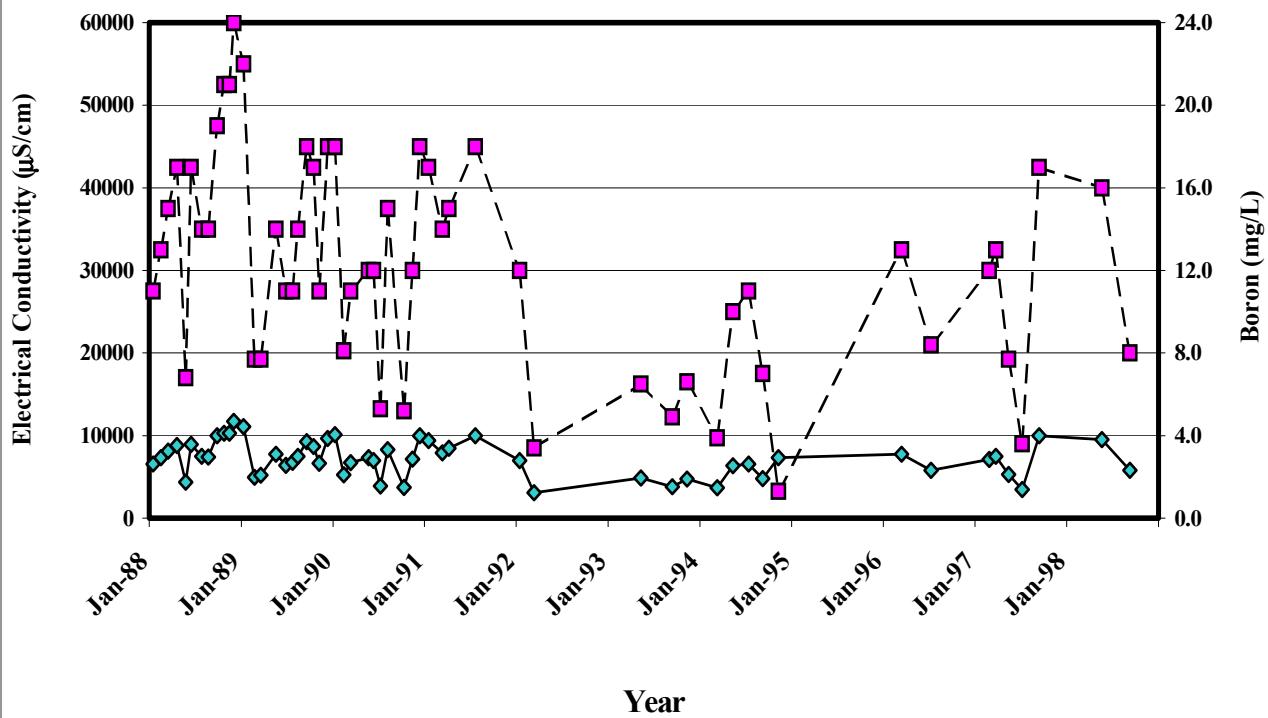
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### Sump FBH 2016

Electrical Conductivity and Boron

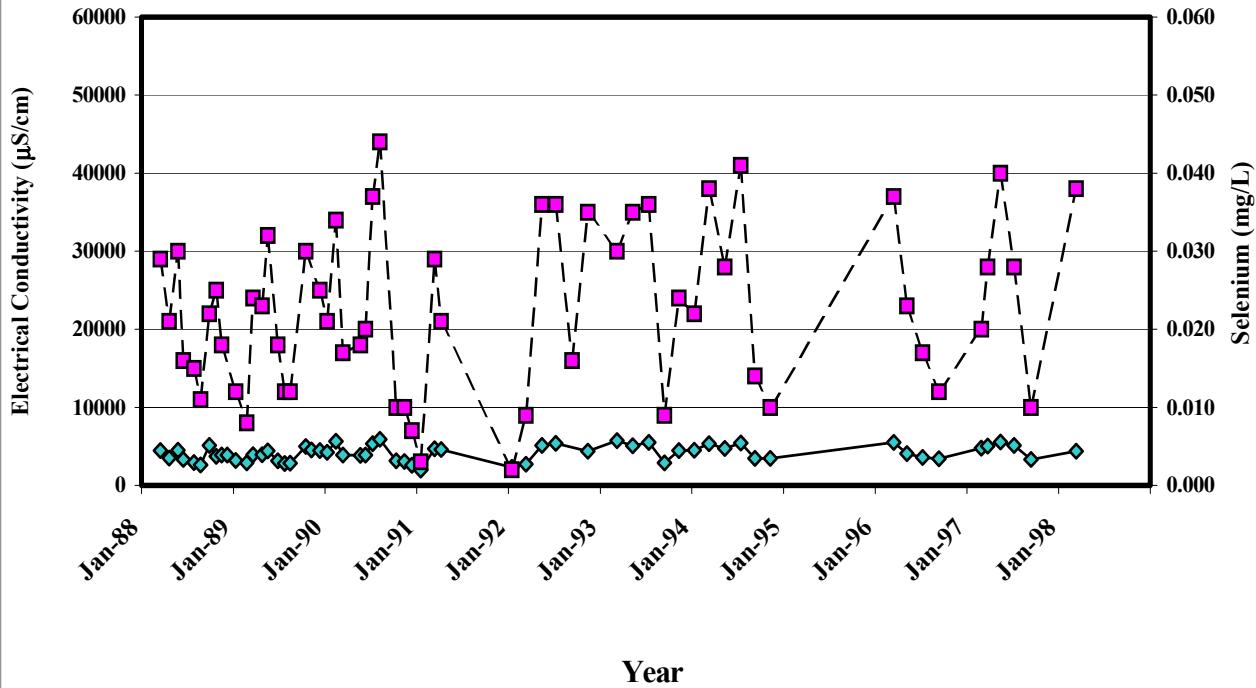
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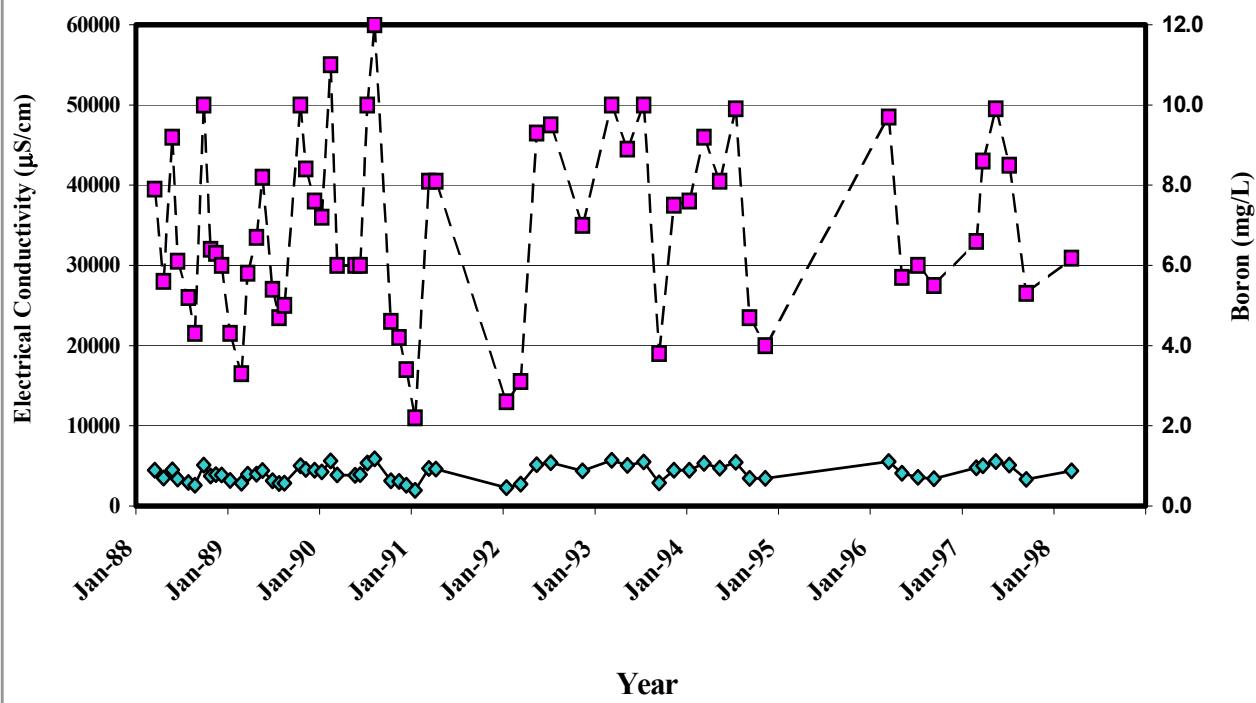
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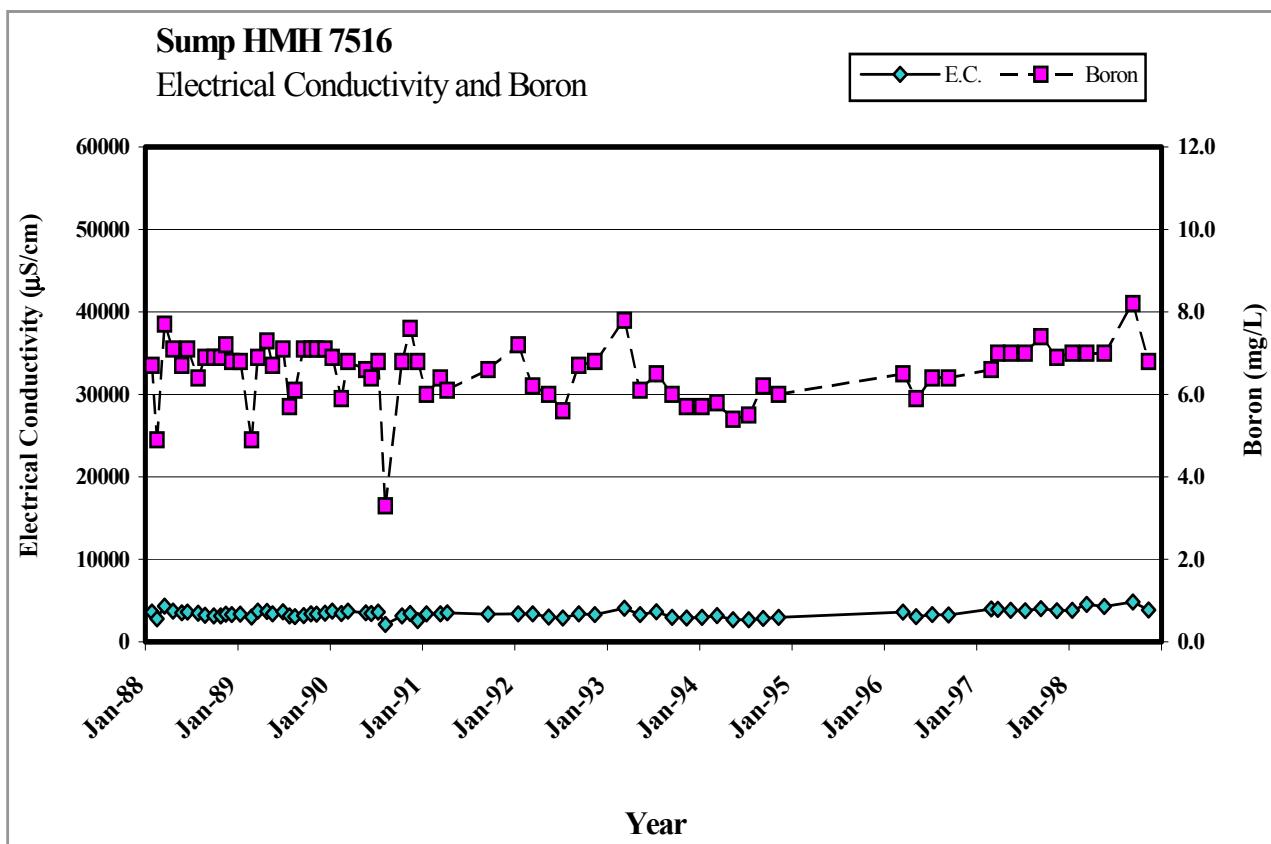
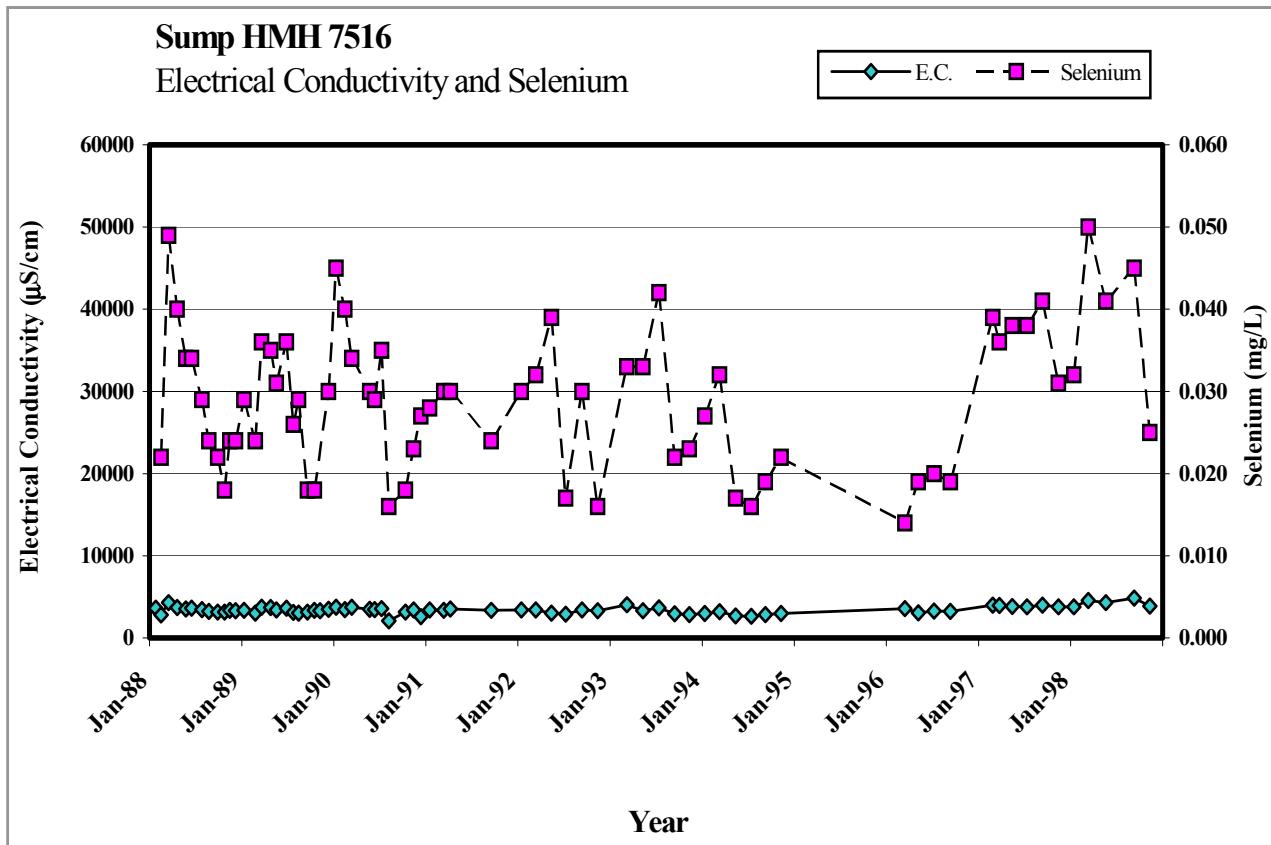


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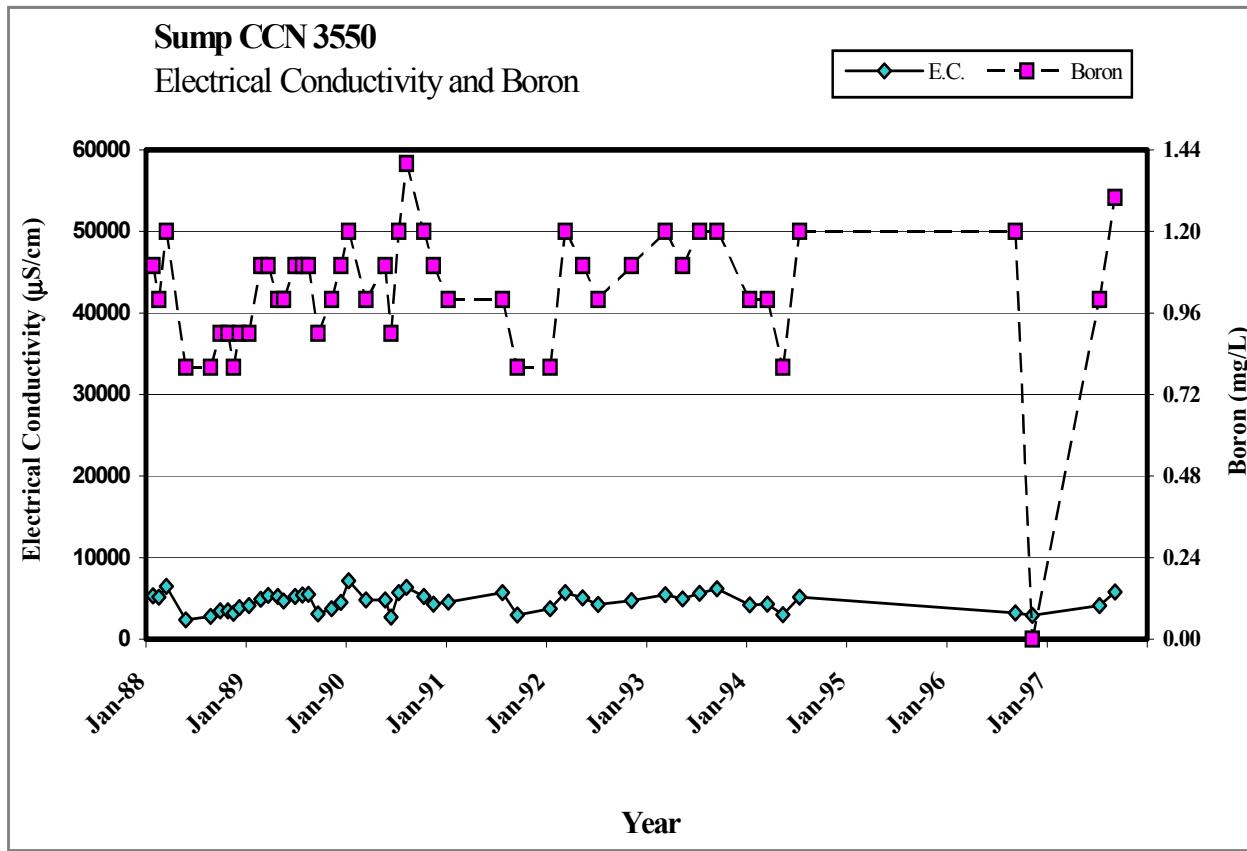
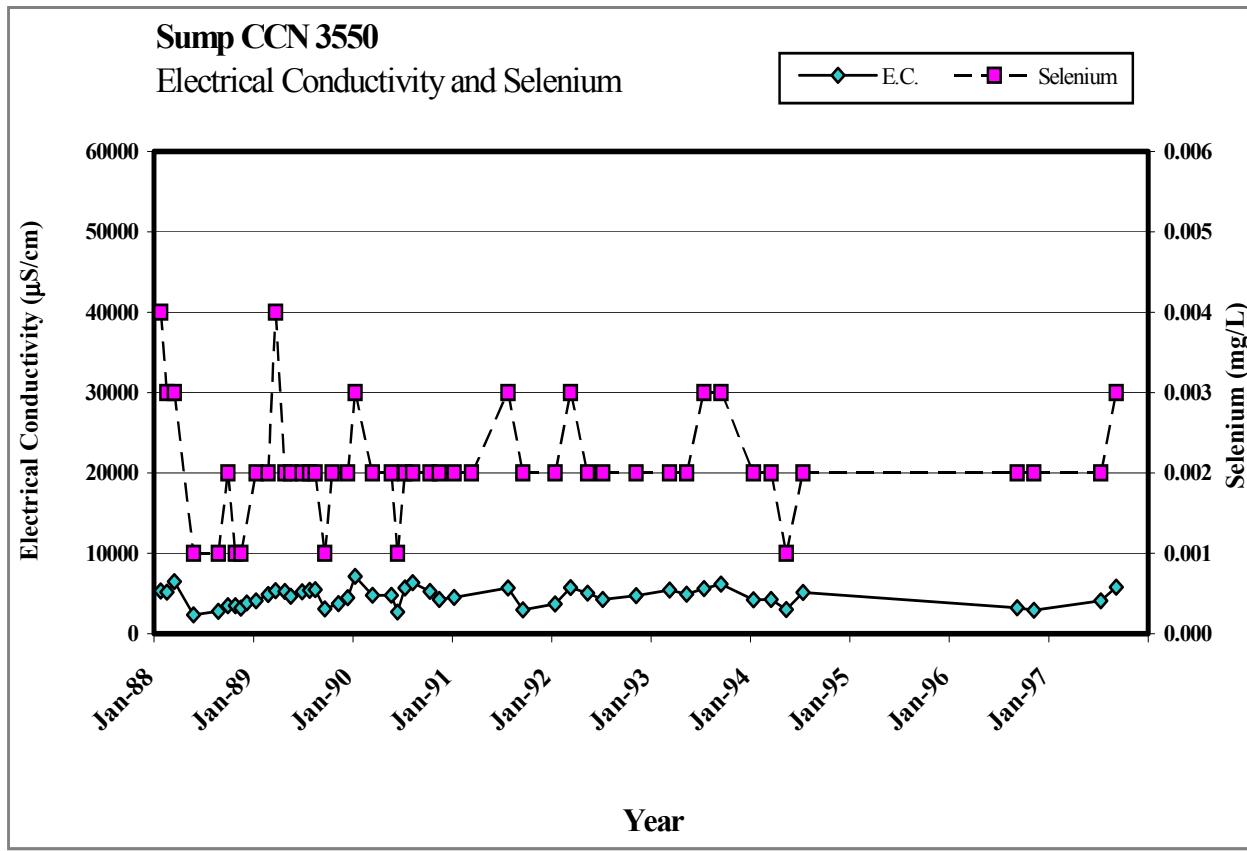
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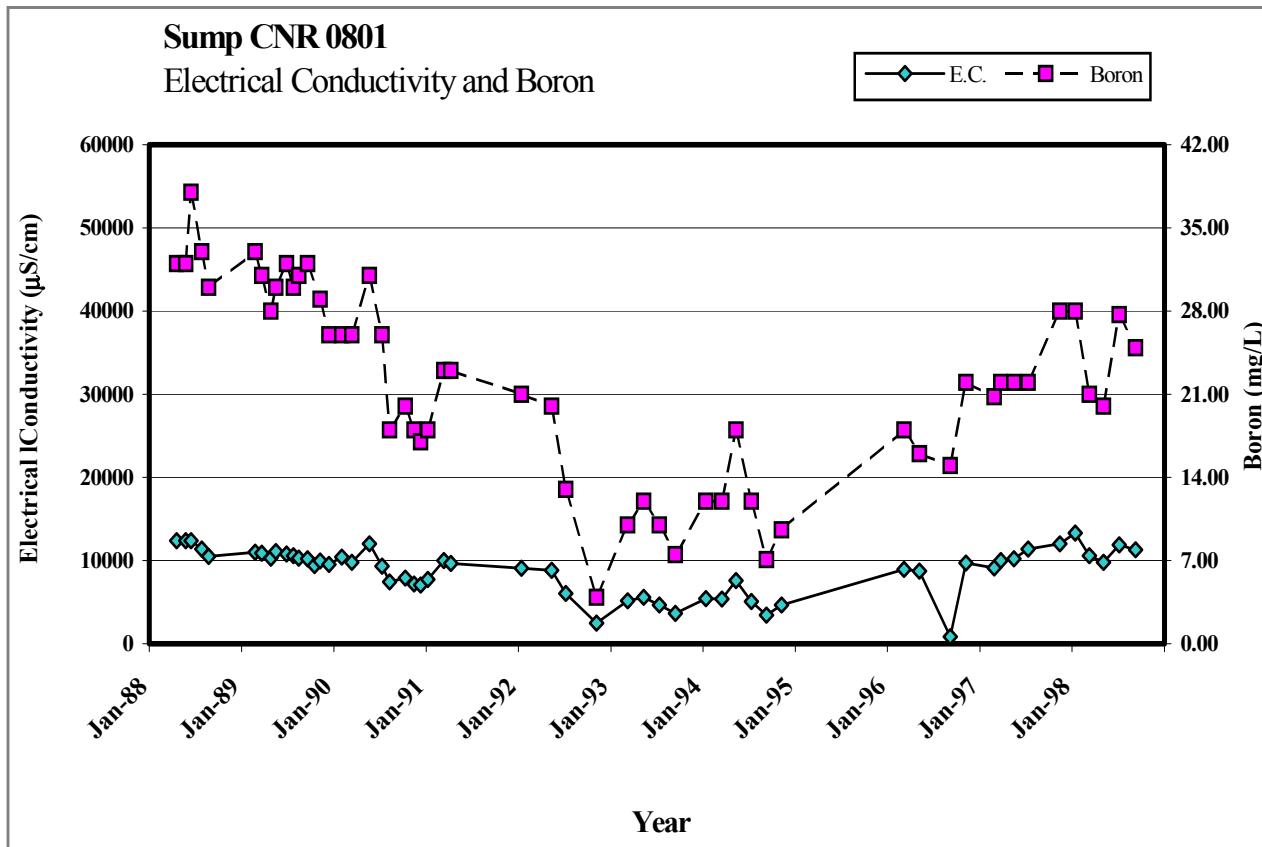
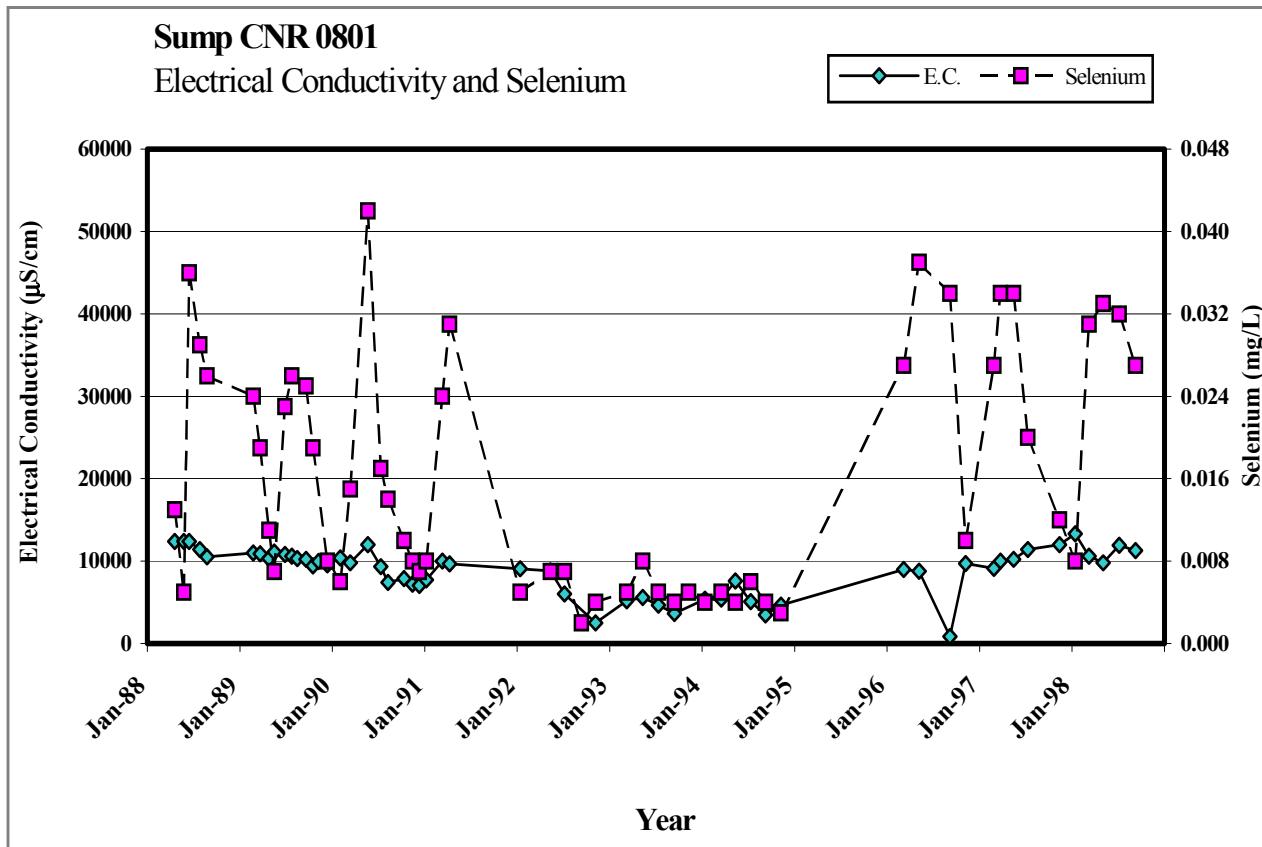
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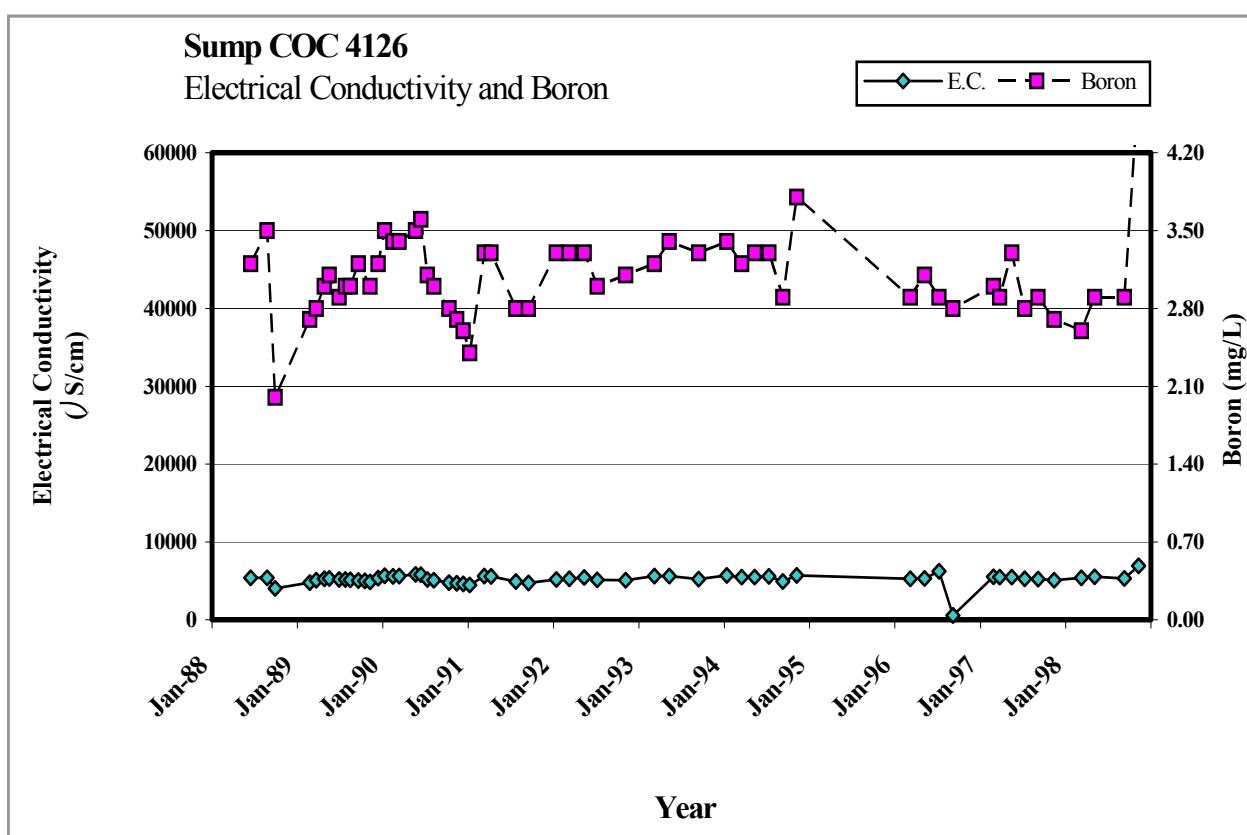
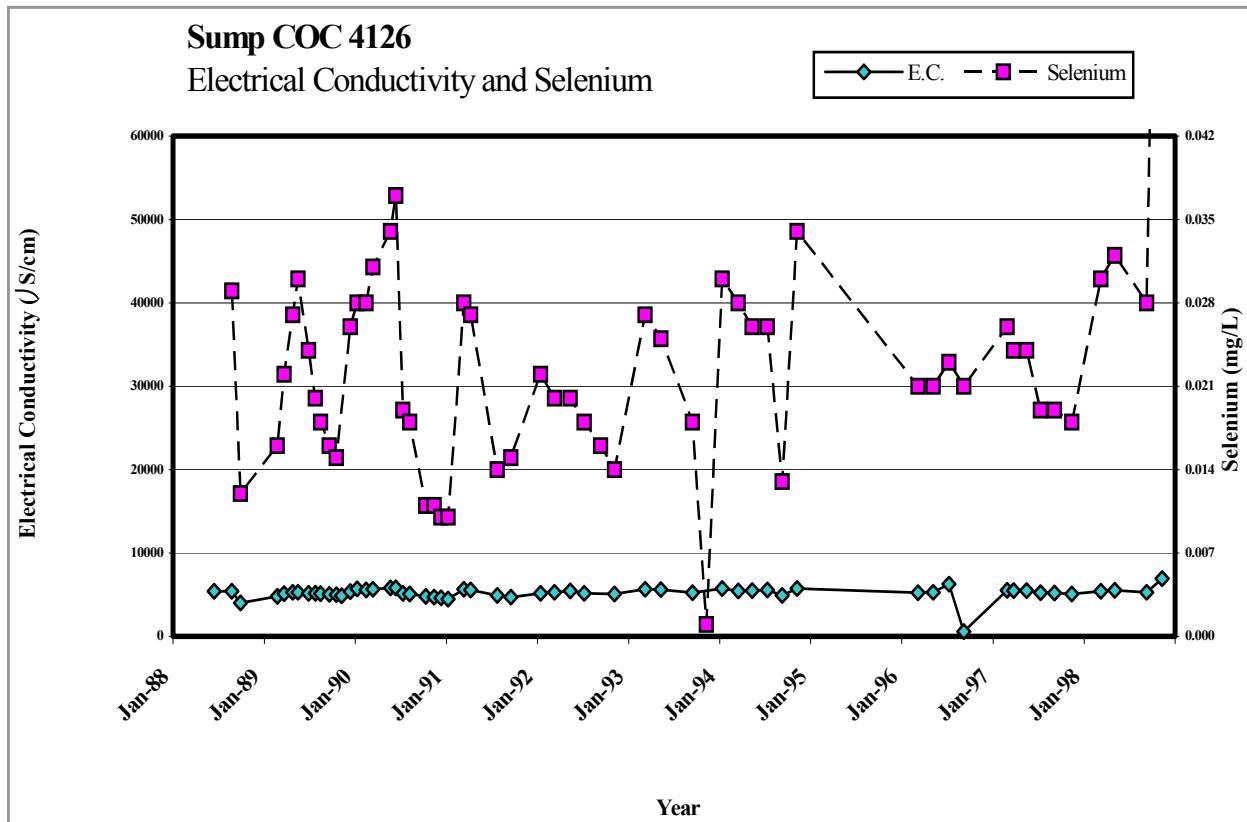


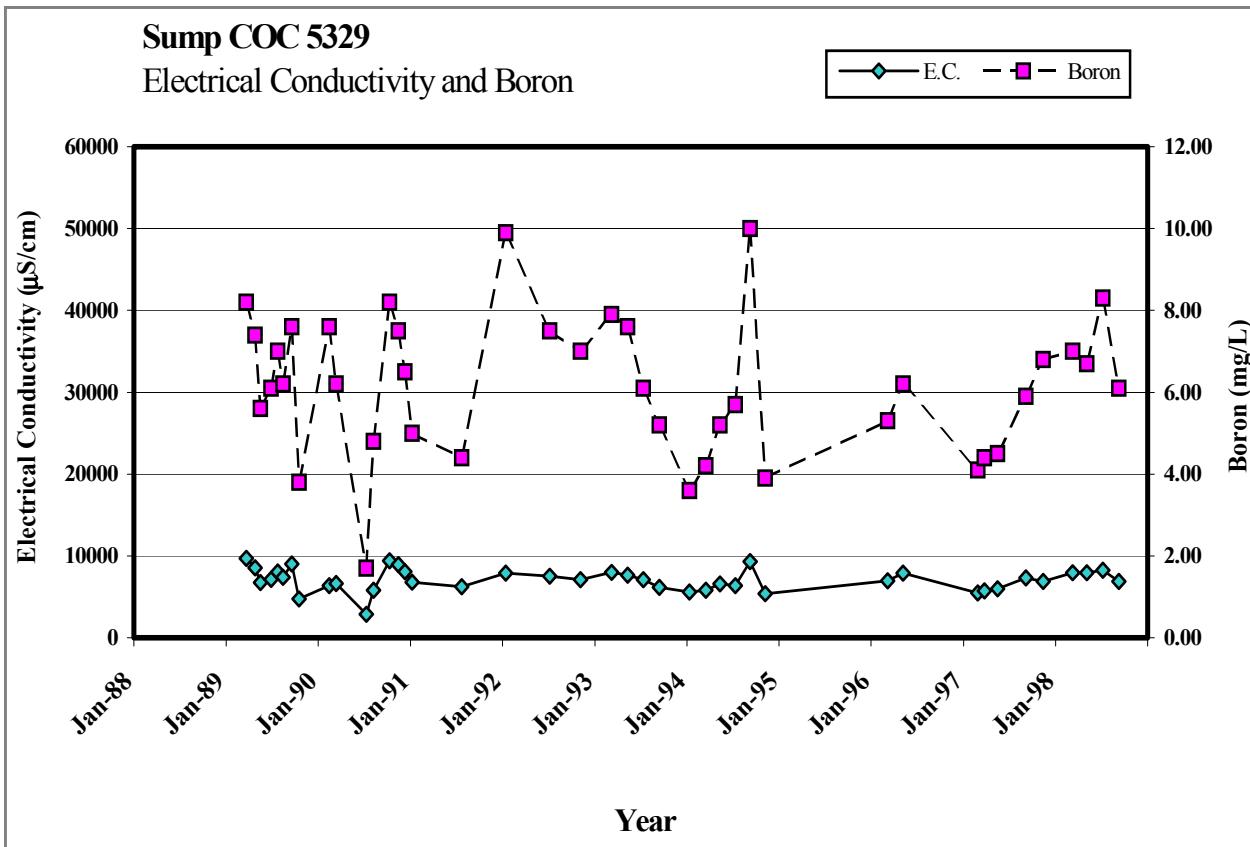
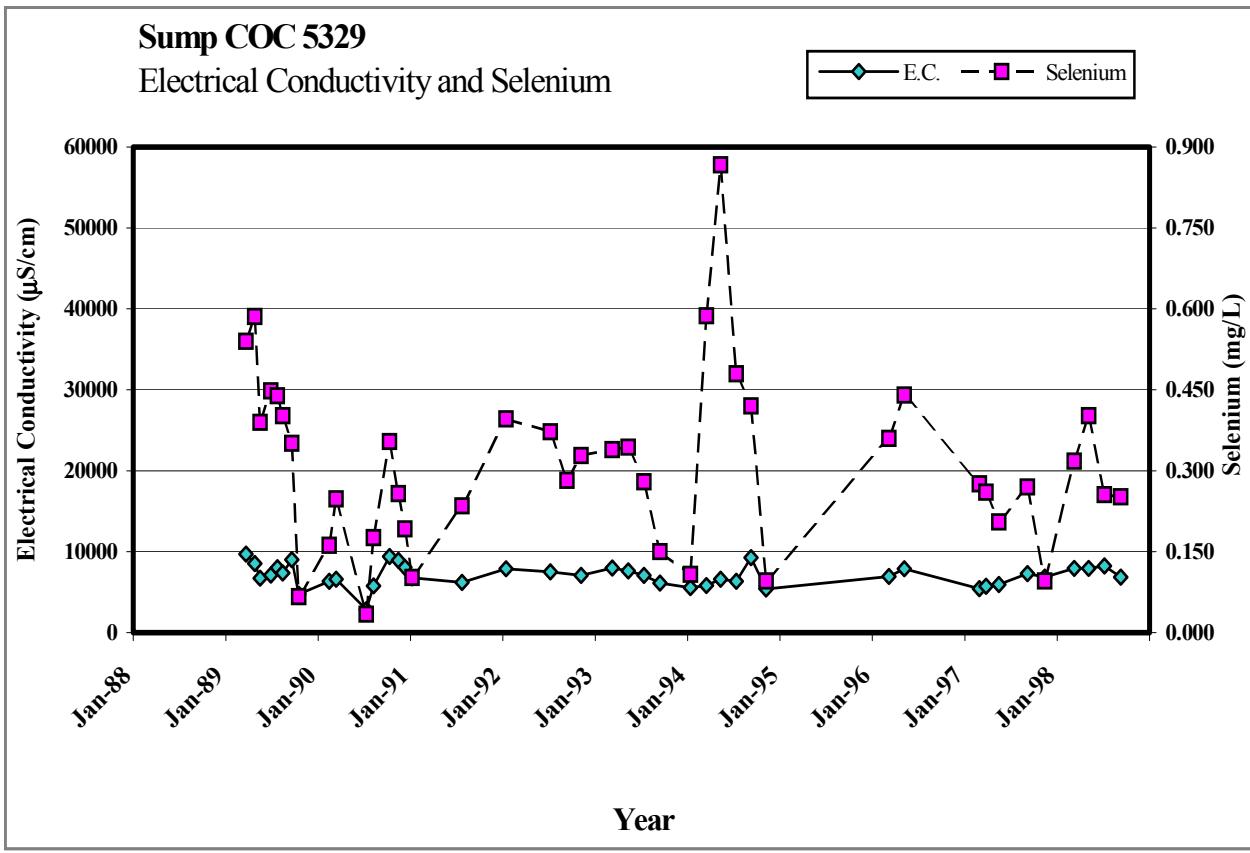


APPENDIX B  
GRAPHS OF WATER QUALITY IN DRAINAGE SUMPS  
SOUTHERN AREA





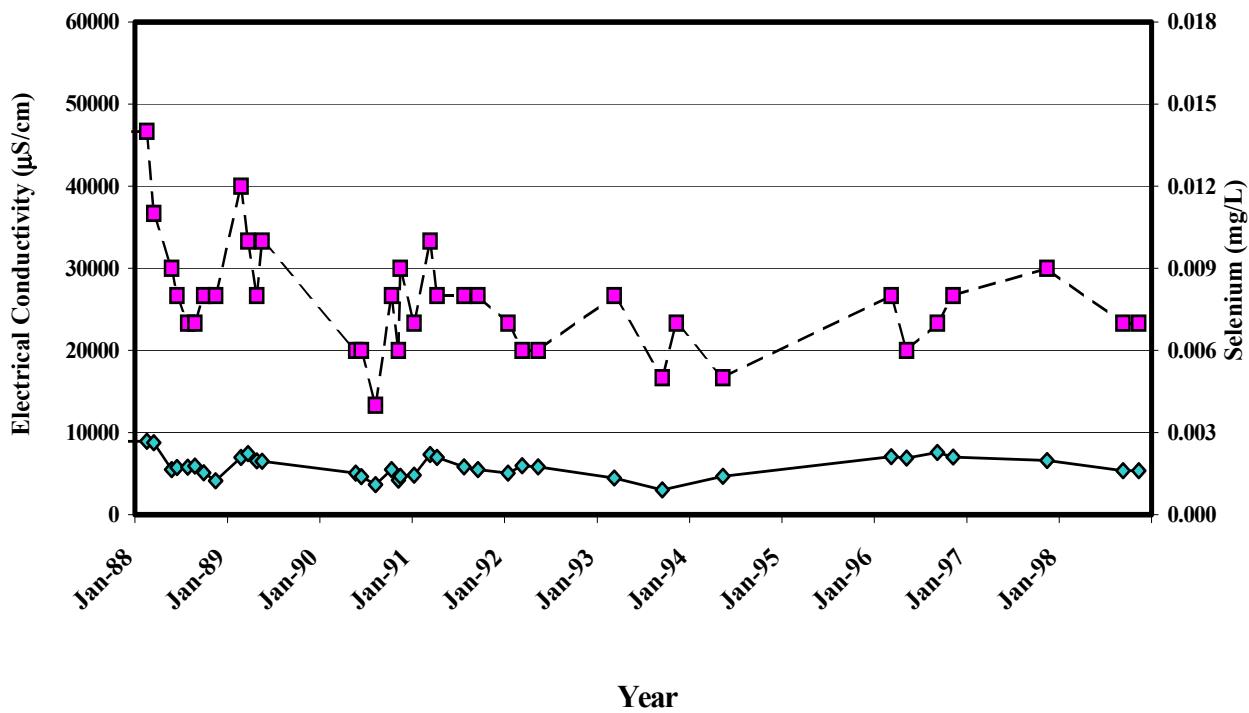




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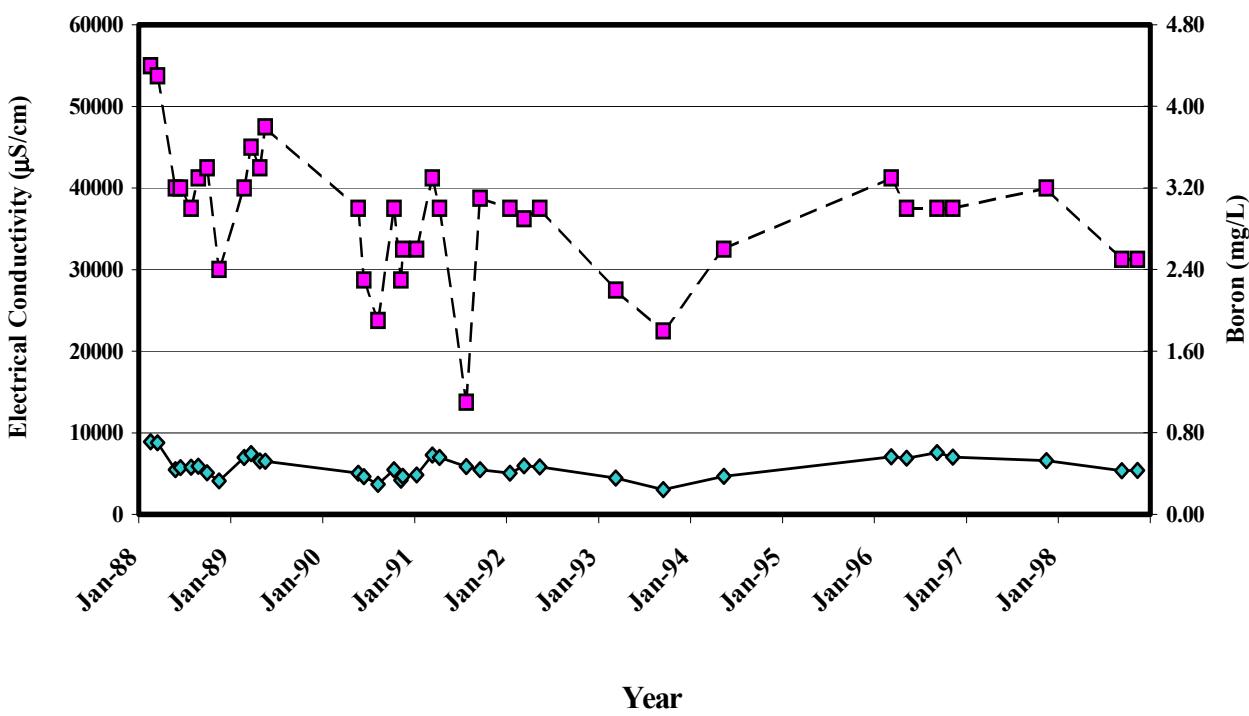
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### Sump ERR 7525

#### Electrical Conductivity and Boron

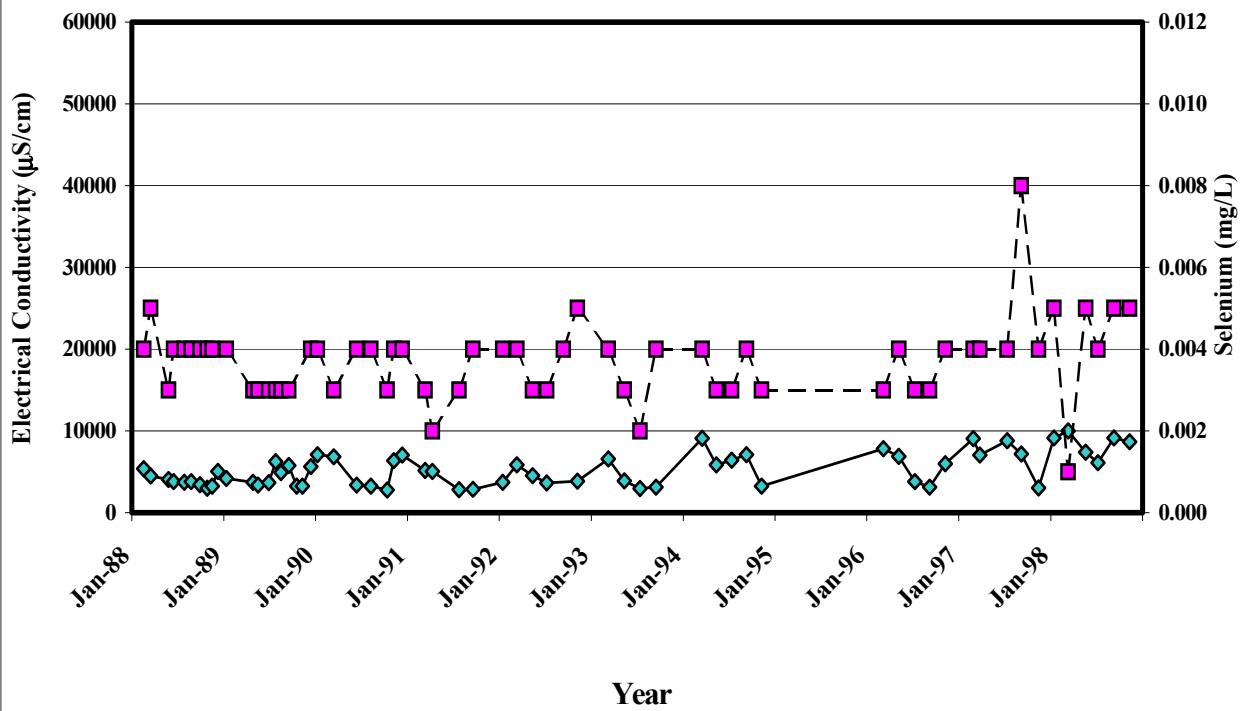
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### Sump ERR 8429

#### Electrical Conductivity and Selenium

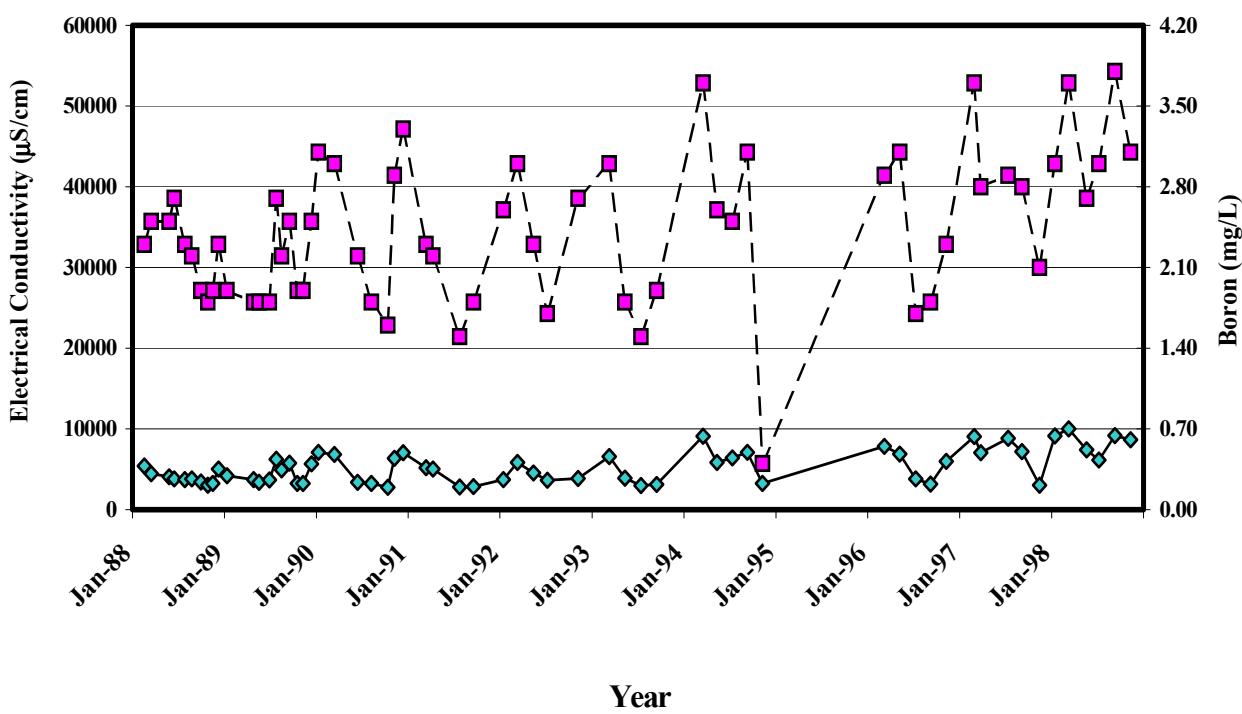
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### Sump ERR 8429

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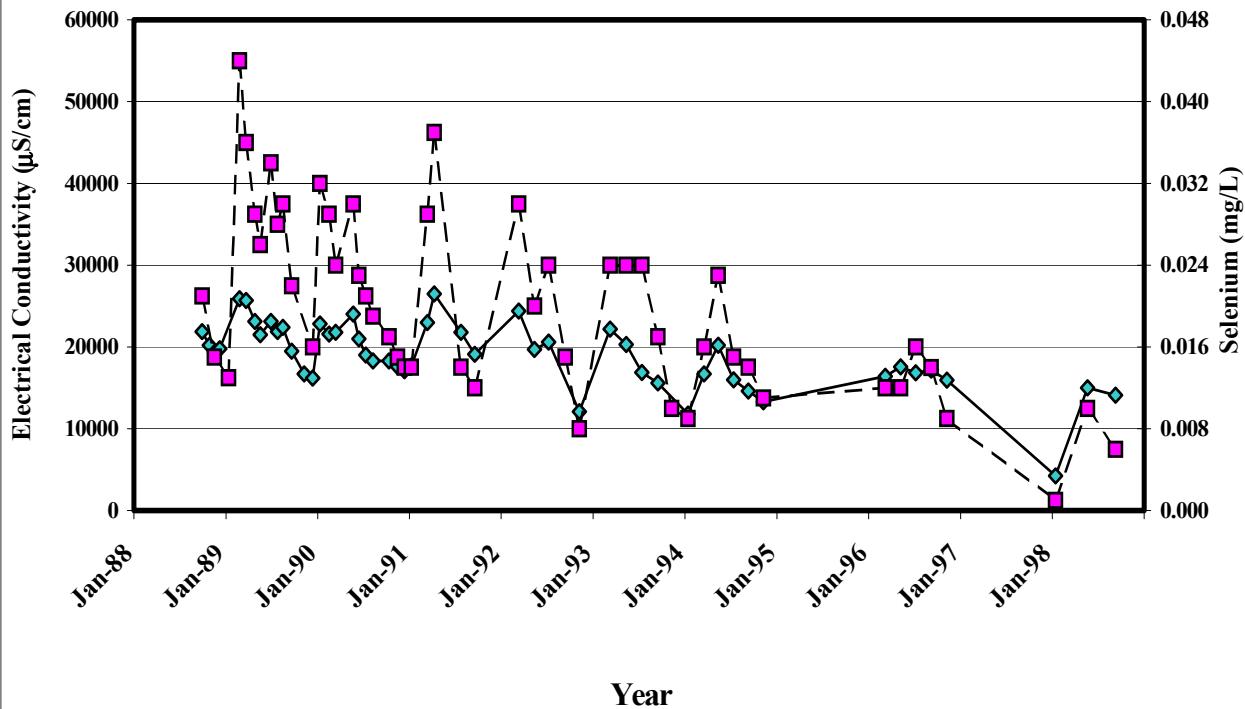
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### Sump ERR 8641

Electrical Conductivity and Selenium

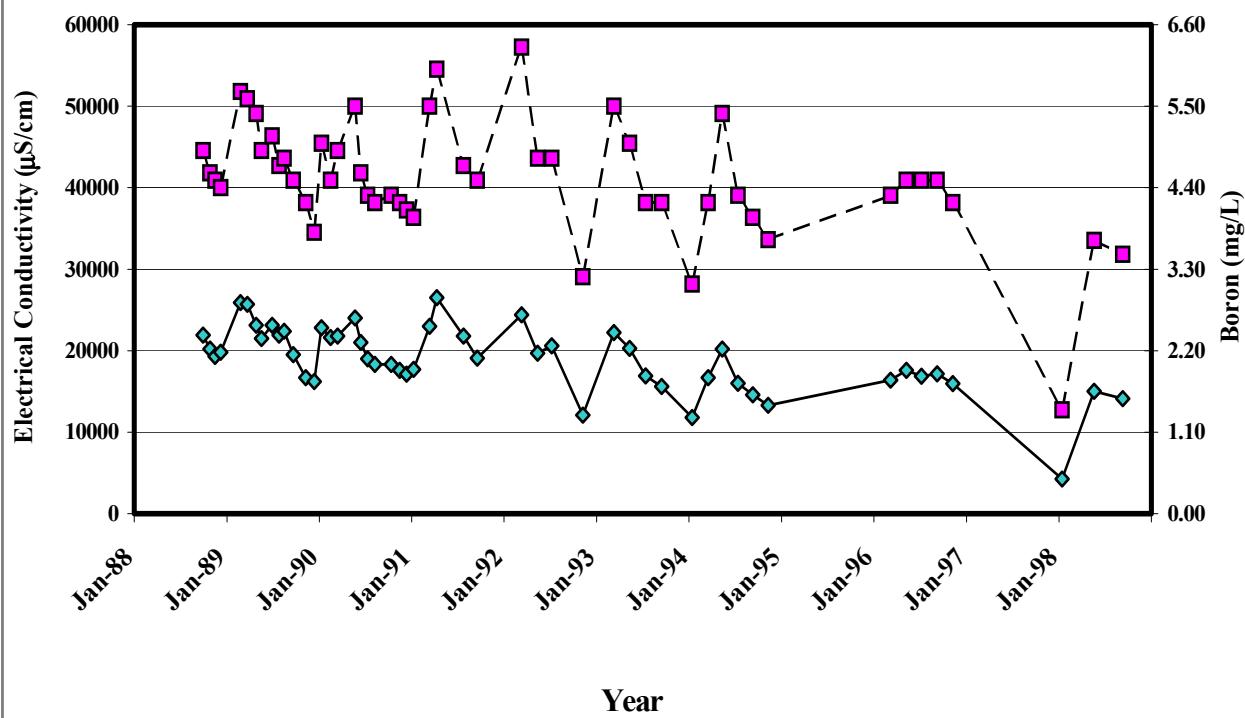
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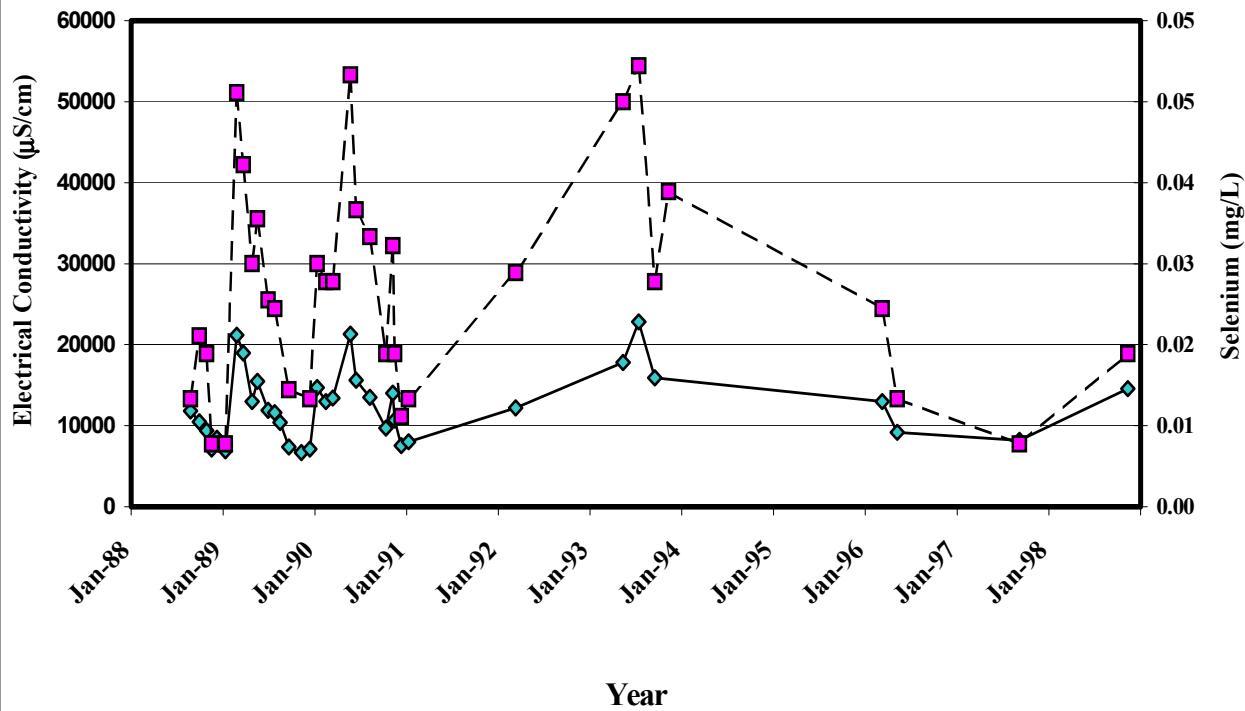
Electrical Conductivity and Boron

— E.C. — Boron



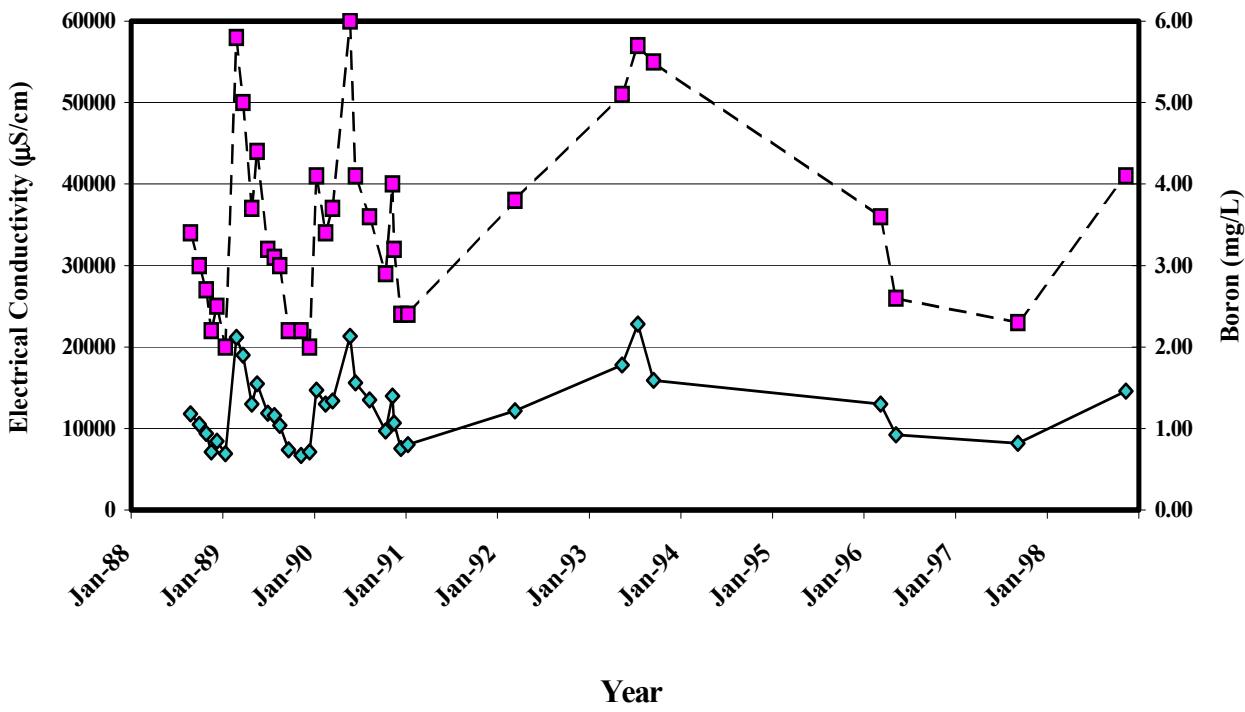
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Electrical Conductivity and Selenium

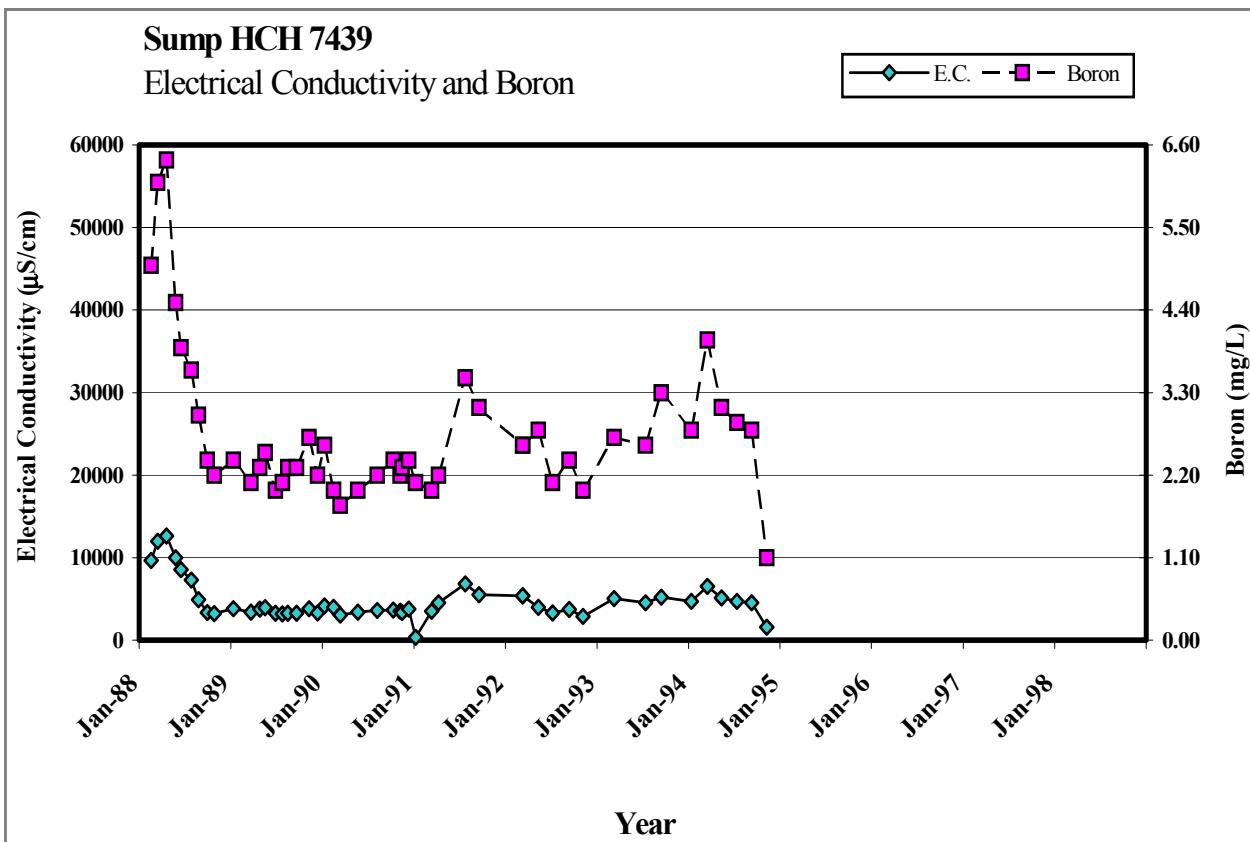
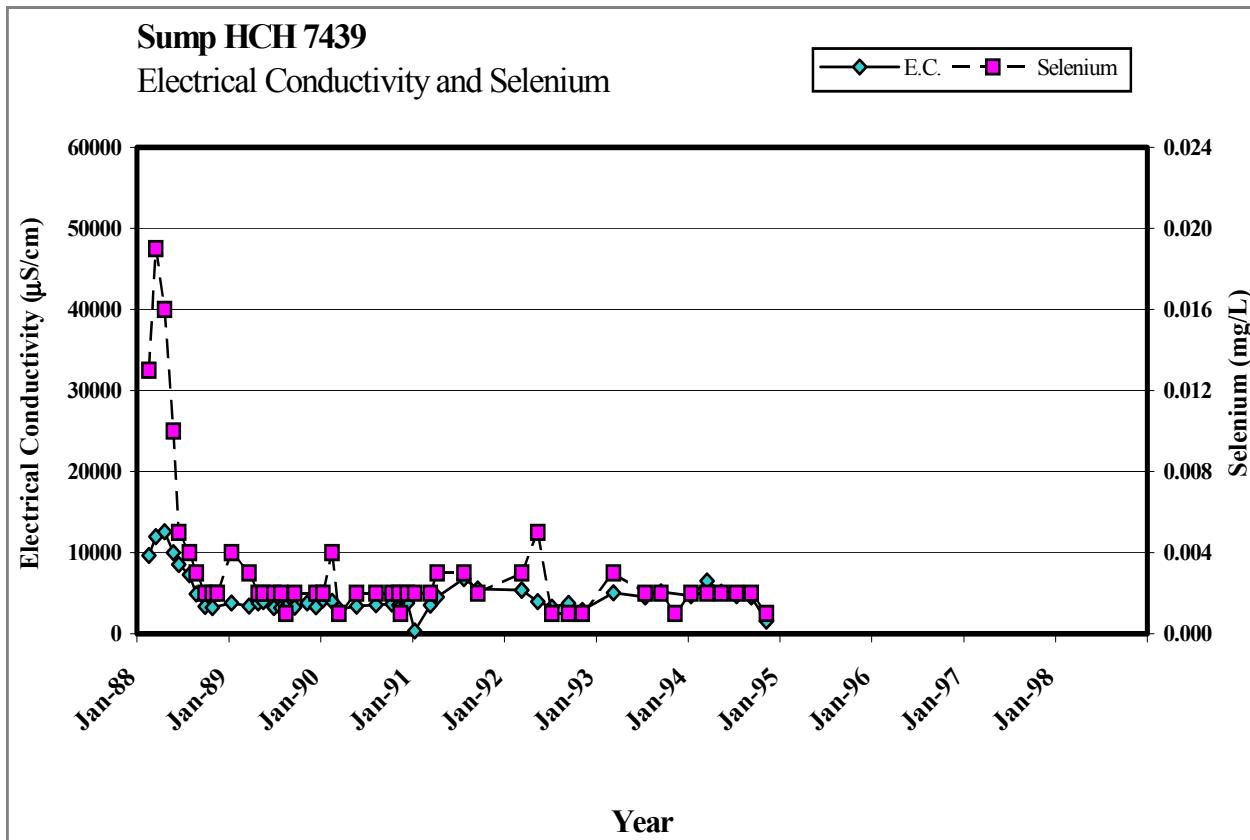
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**Sump GSY 0855**  
Electrical Conductivity and Boron

— E.C. — Boron

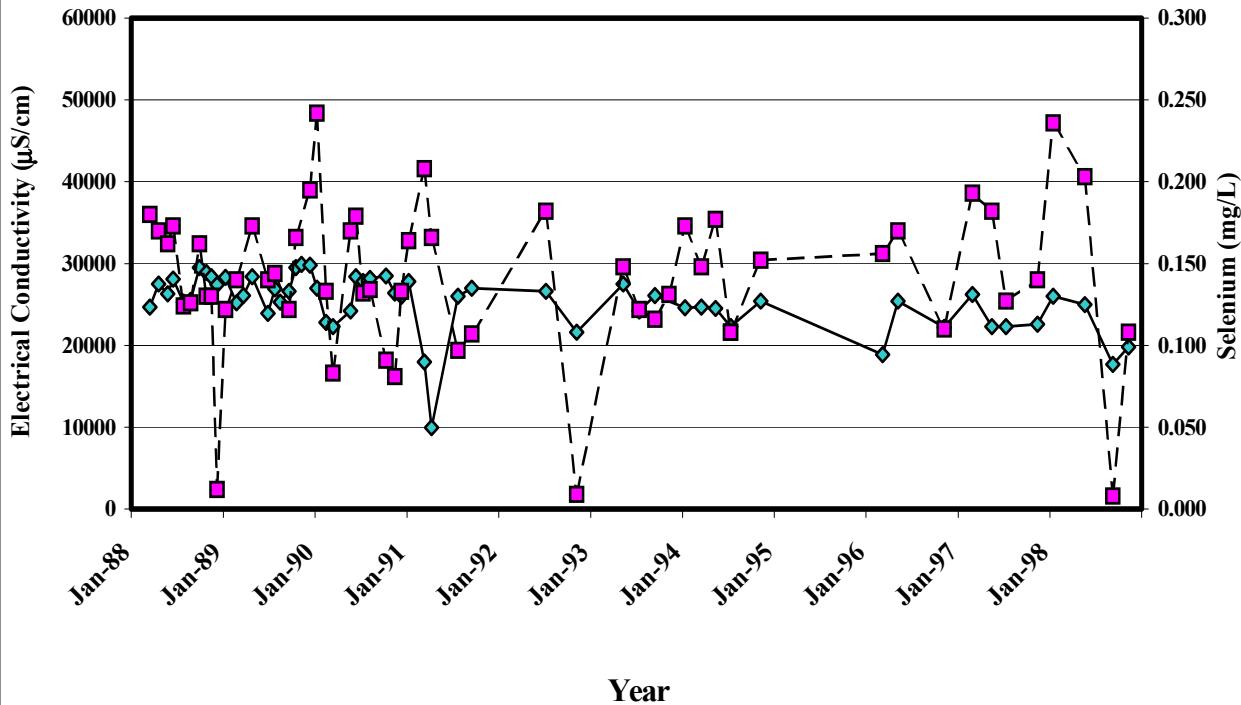




### Sump LNW 5454

Electrical Conductivity and Selenium

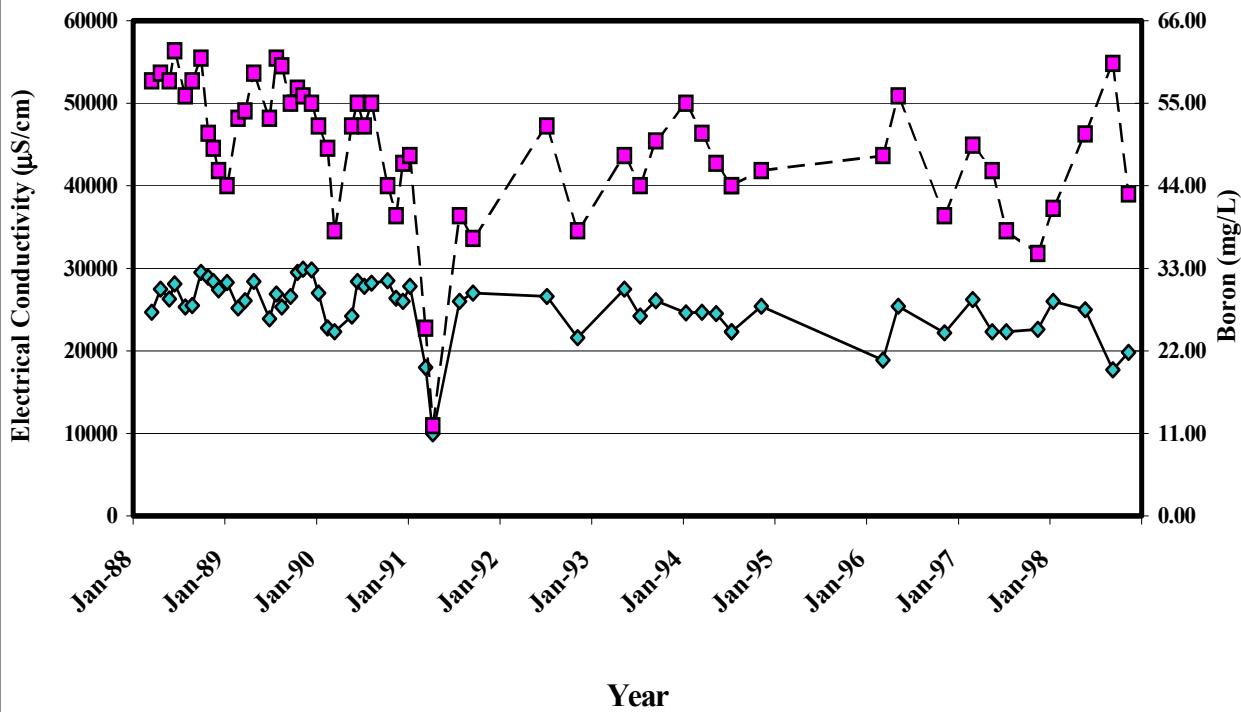
— E.C. — ■ — Selenium

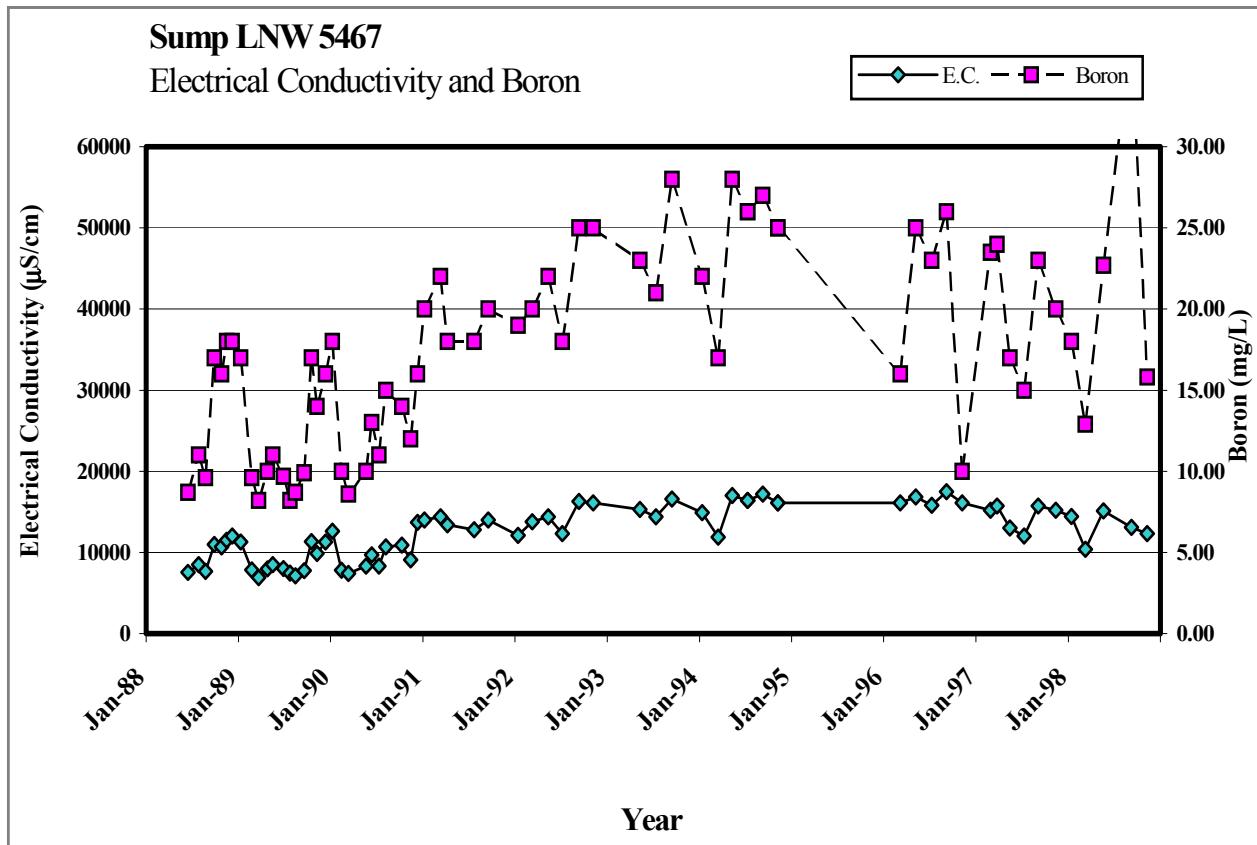
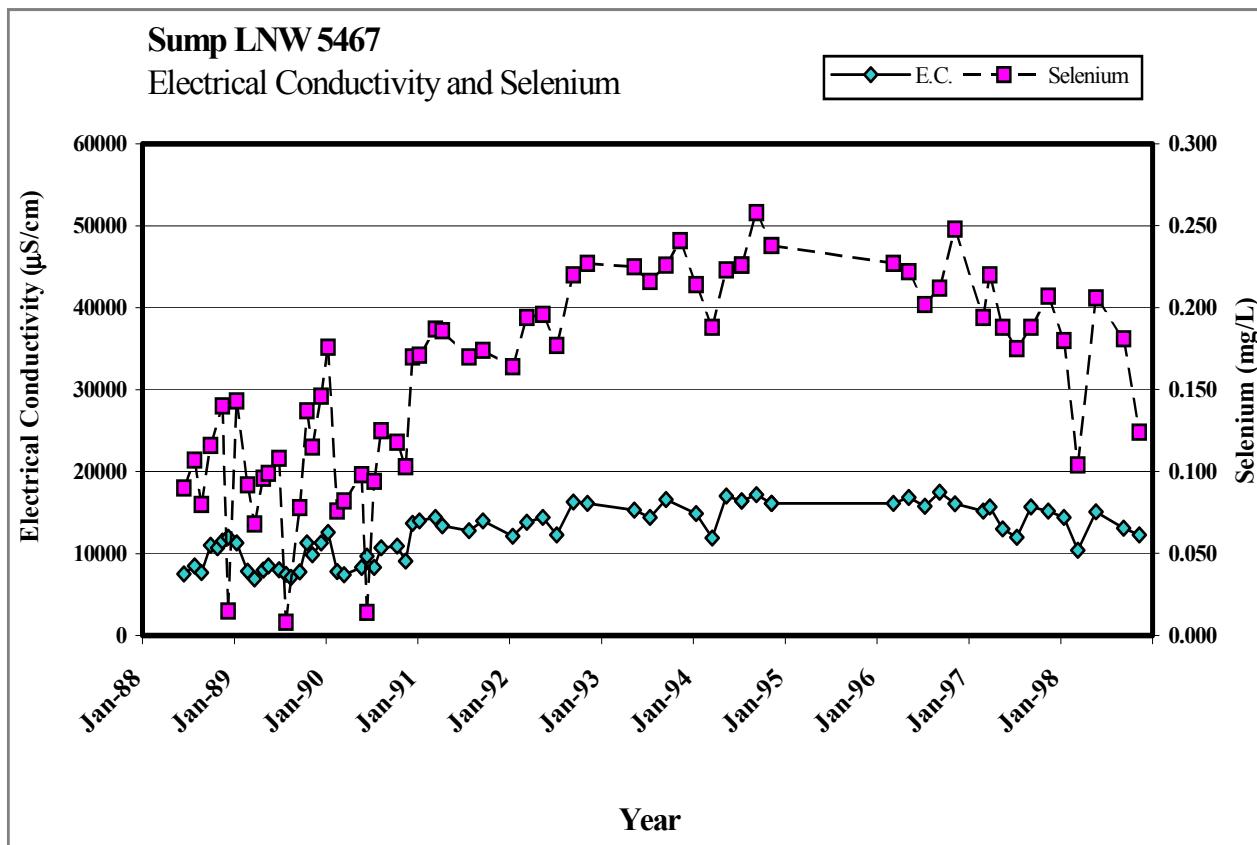


### Sump LNW 5454

Electrical Conductivity and Boron

— E.C. — ■ — Boron

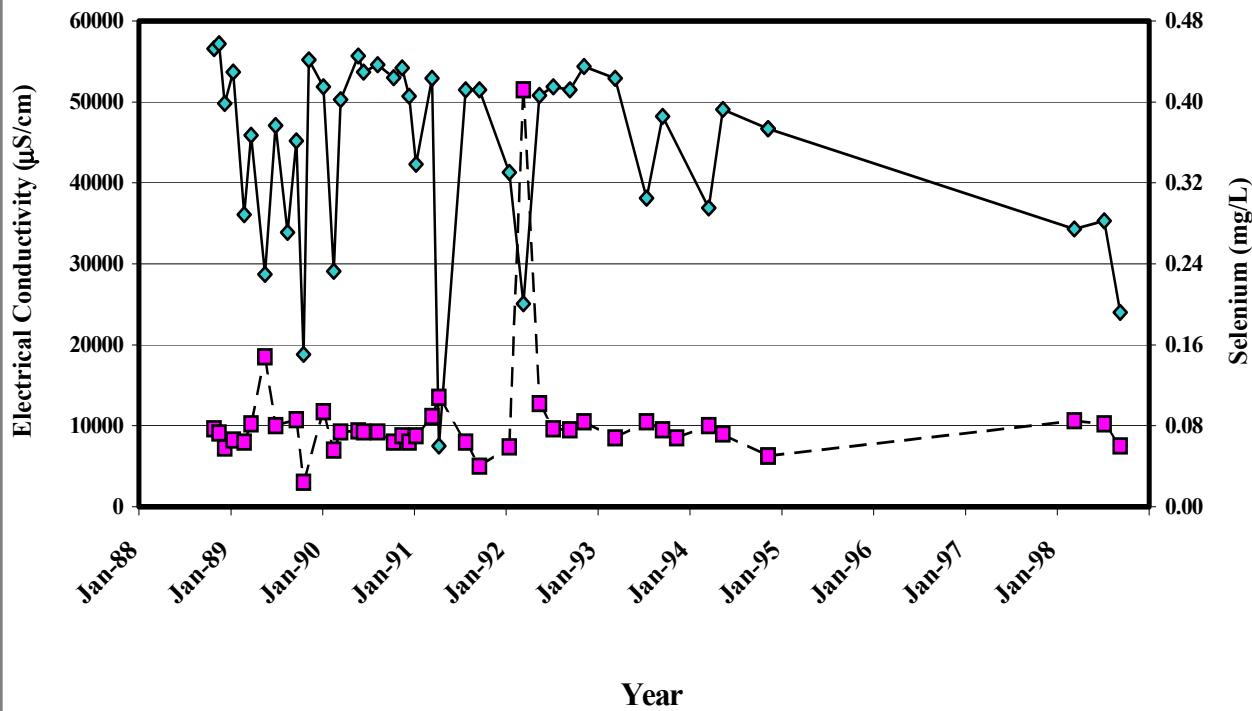




### Sump LNW 6459

#### Electrical Conductivity and Selenium

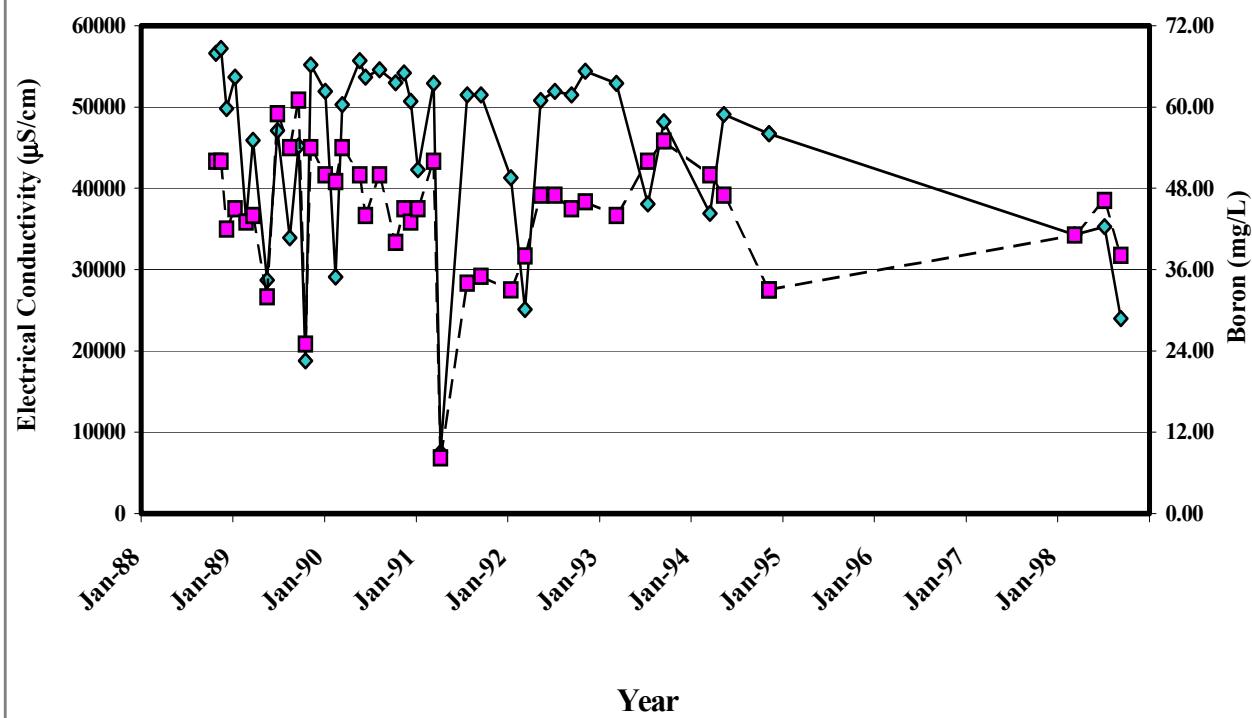
— E.C. — Selenium



### Sump LNW 6459

#### Electrical Conductivity and Boron

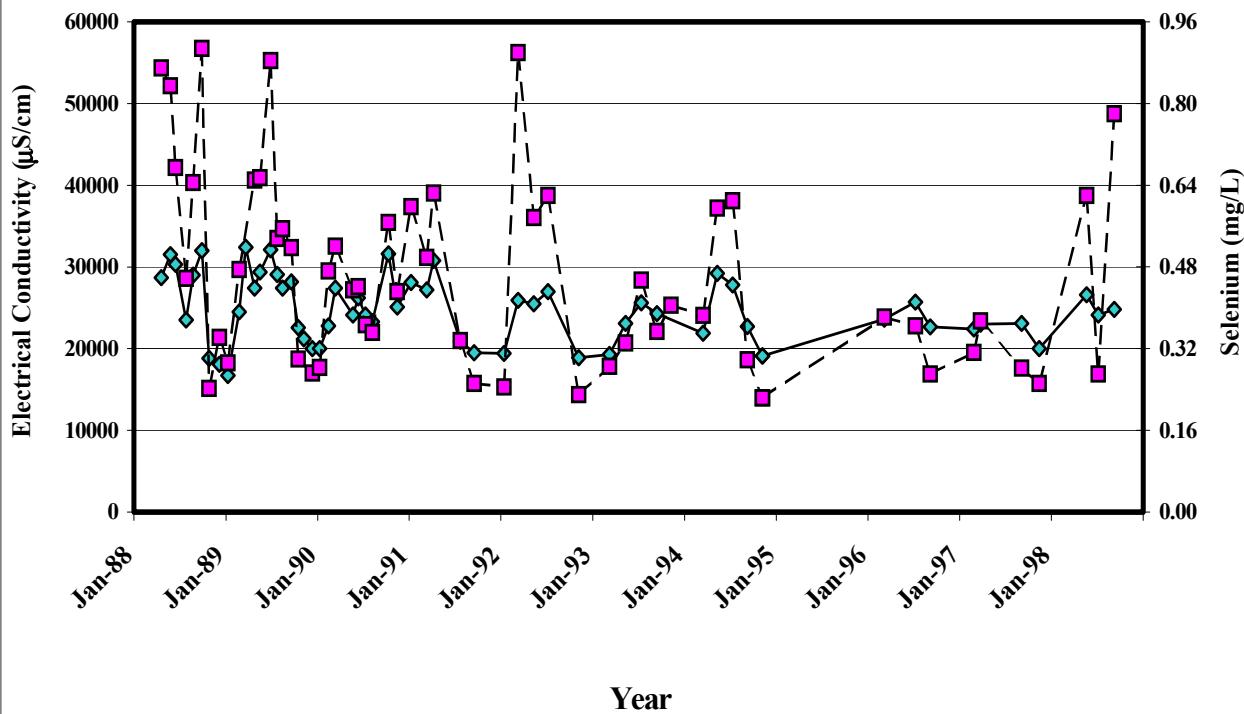
— E.C. — Boron



### Sump LNW 6467

Electrical Conductivity and Selenium

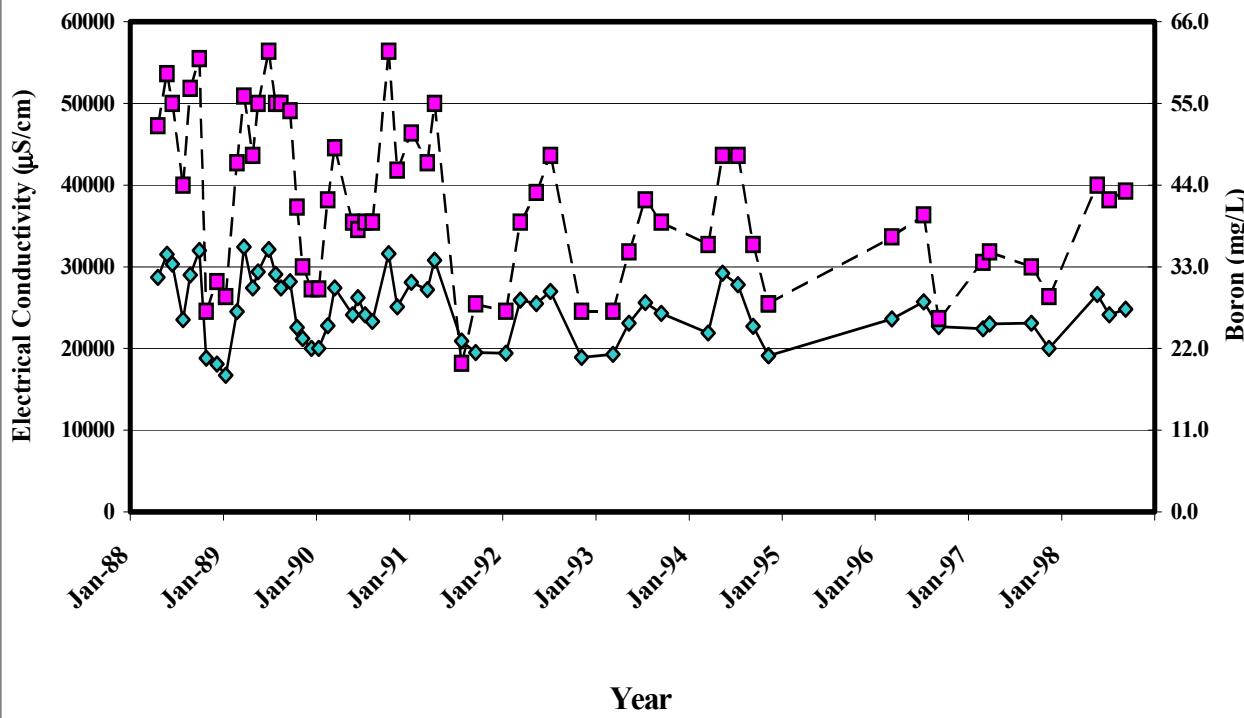
— E.C. — ■ — Selenium

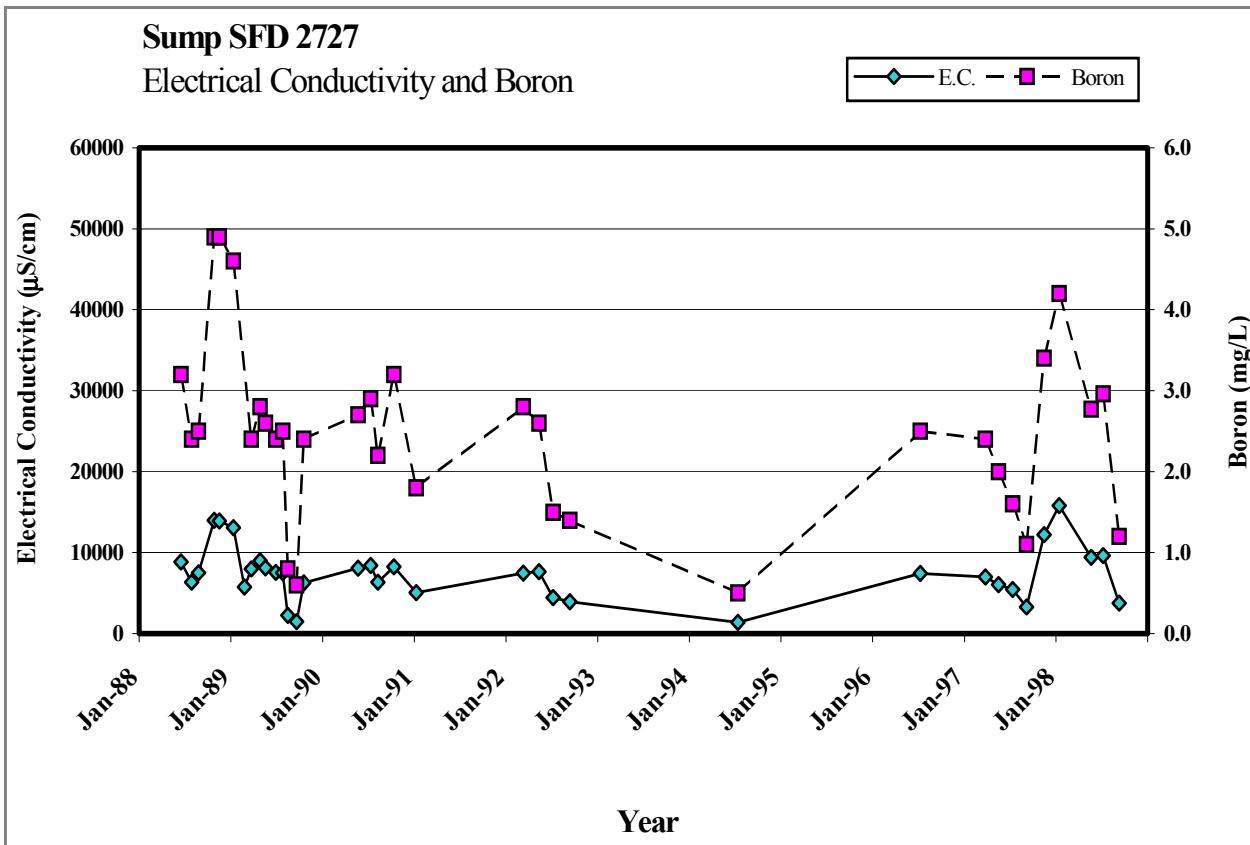
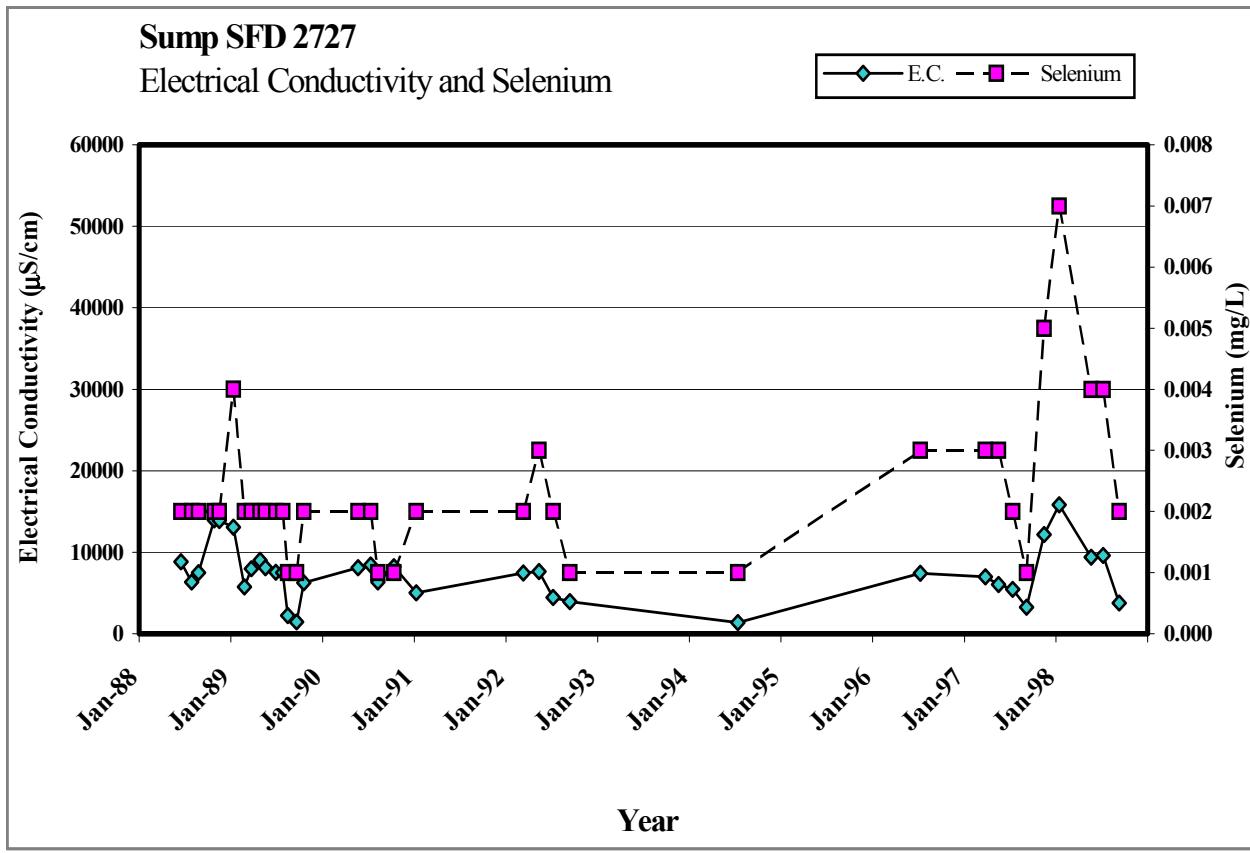


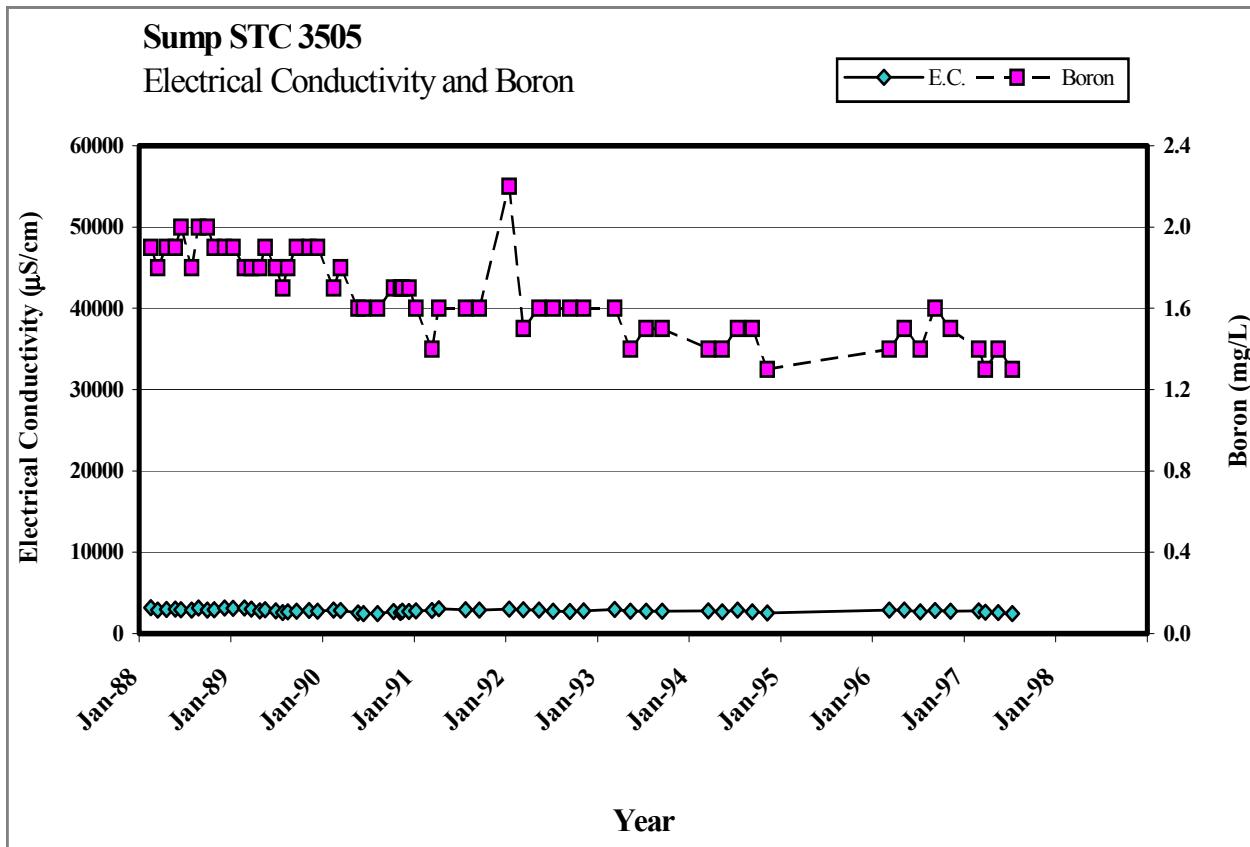
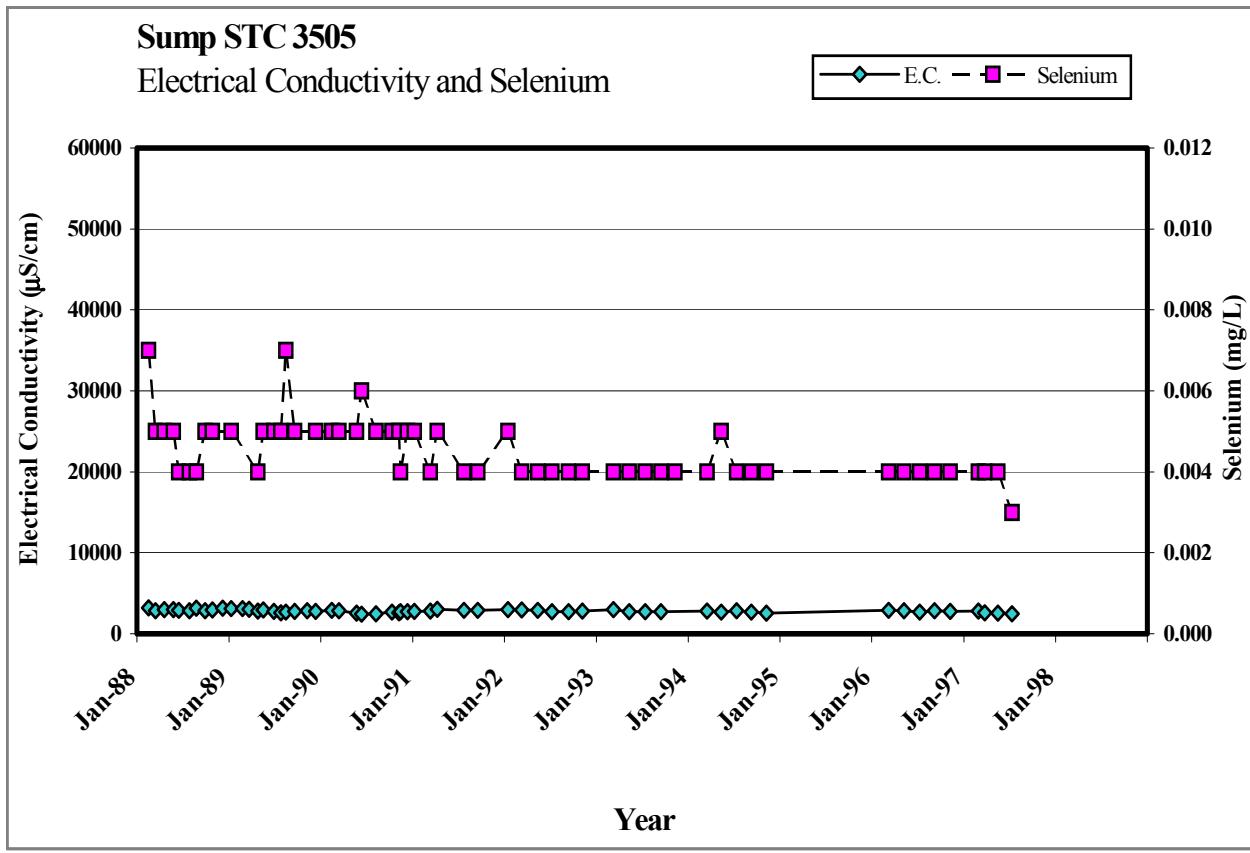
### Sump LNW 6467

Electrical Conductivity and Boron

— E.C. — ■ — Boron



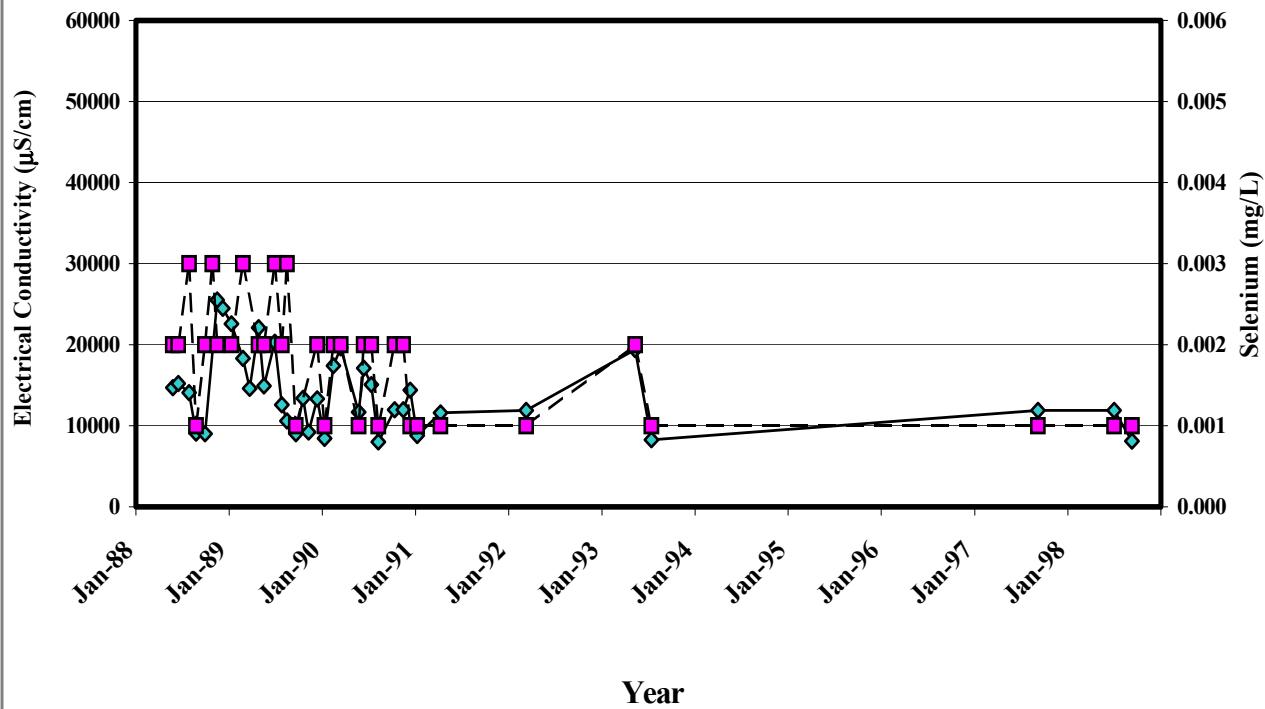




### Sump STC 5436

Electrical Conductivity and Selenium

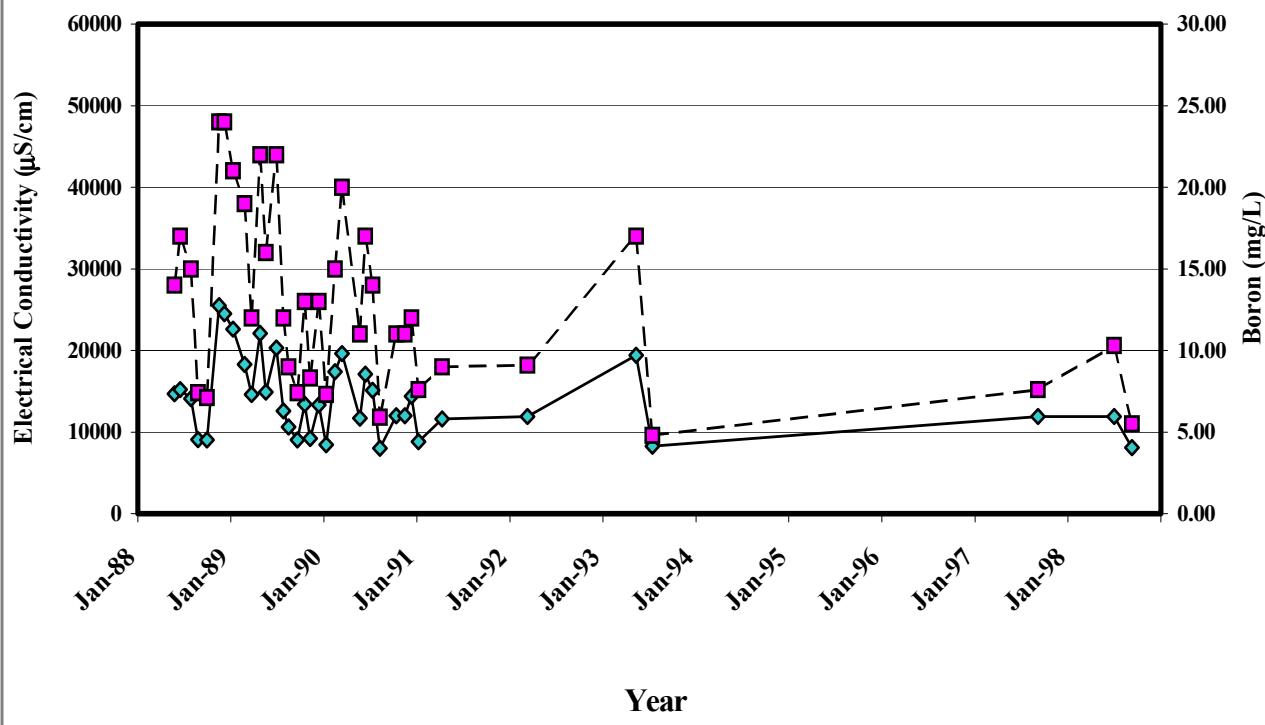
— E.C — Selenium

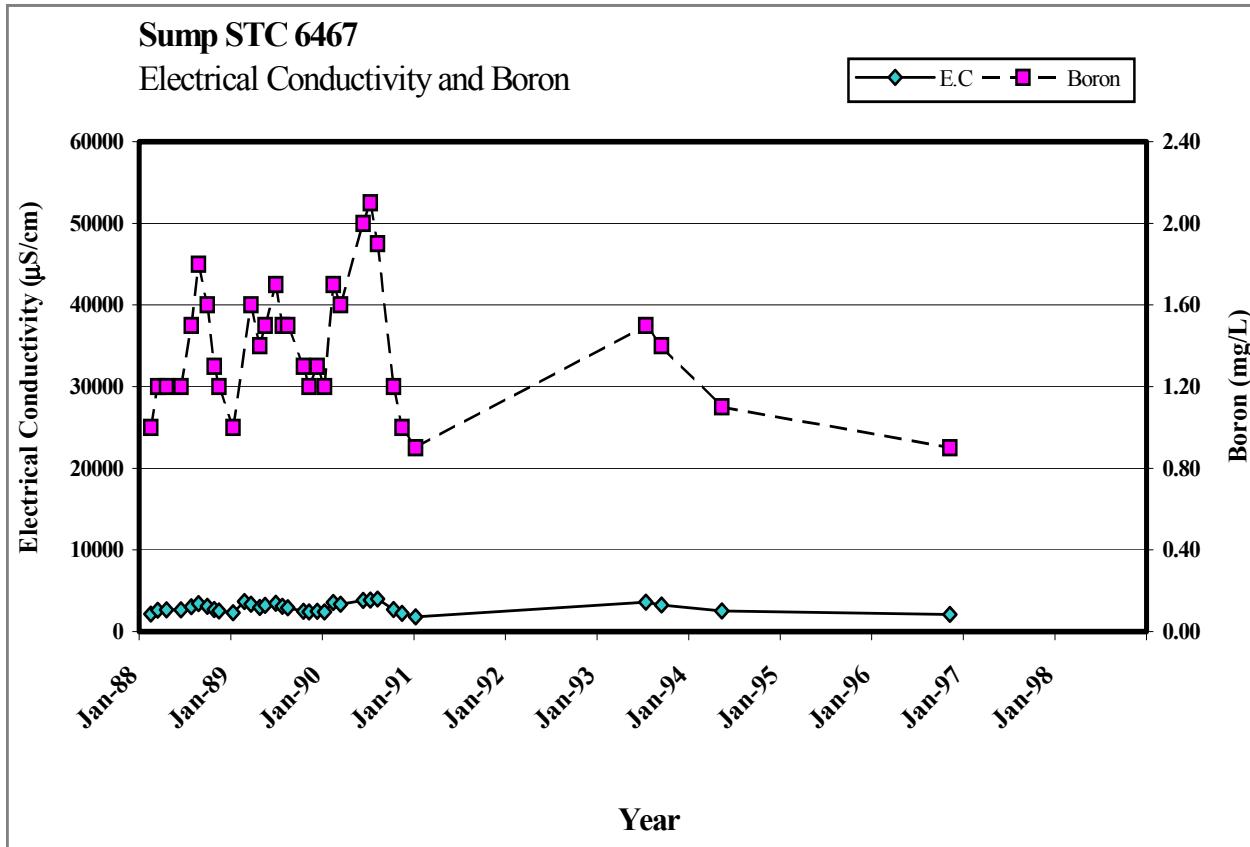
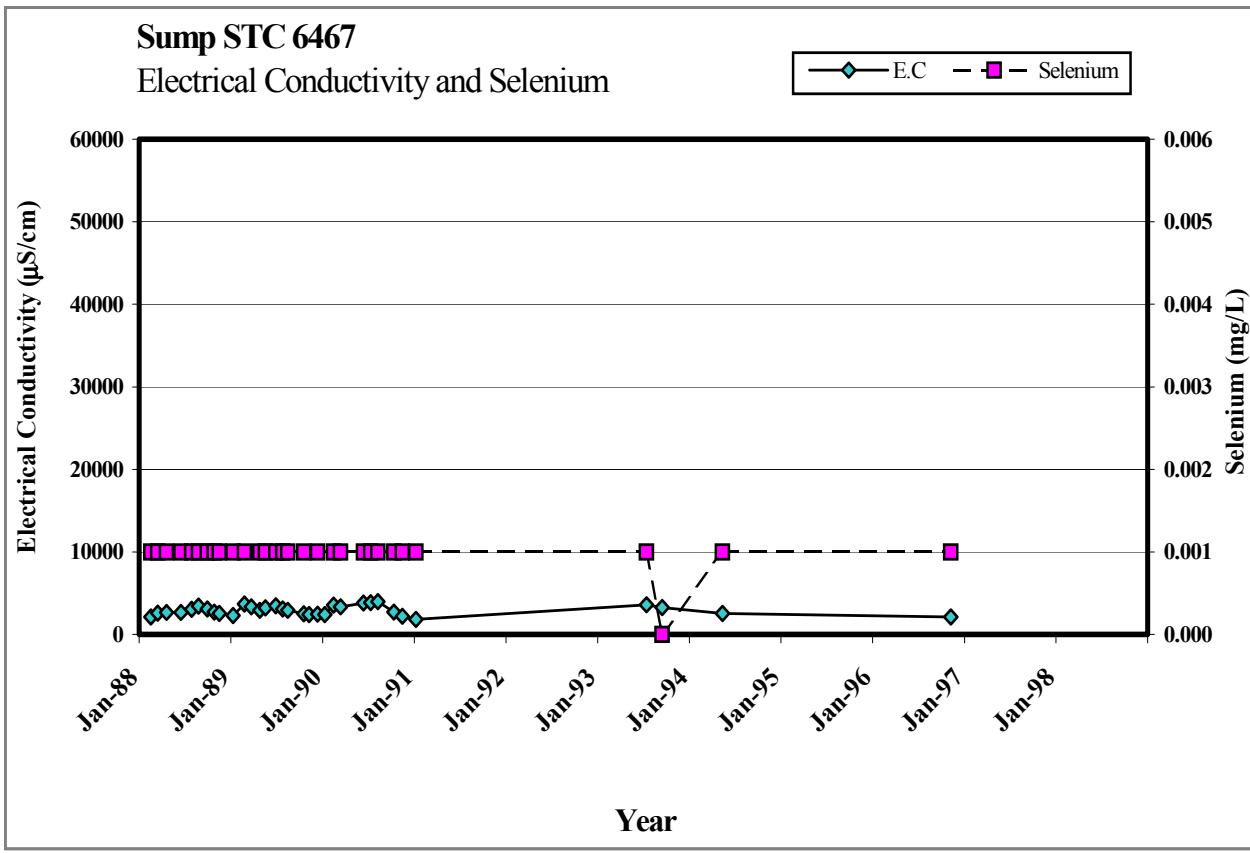


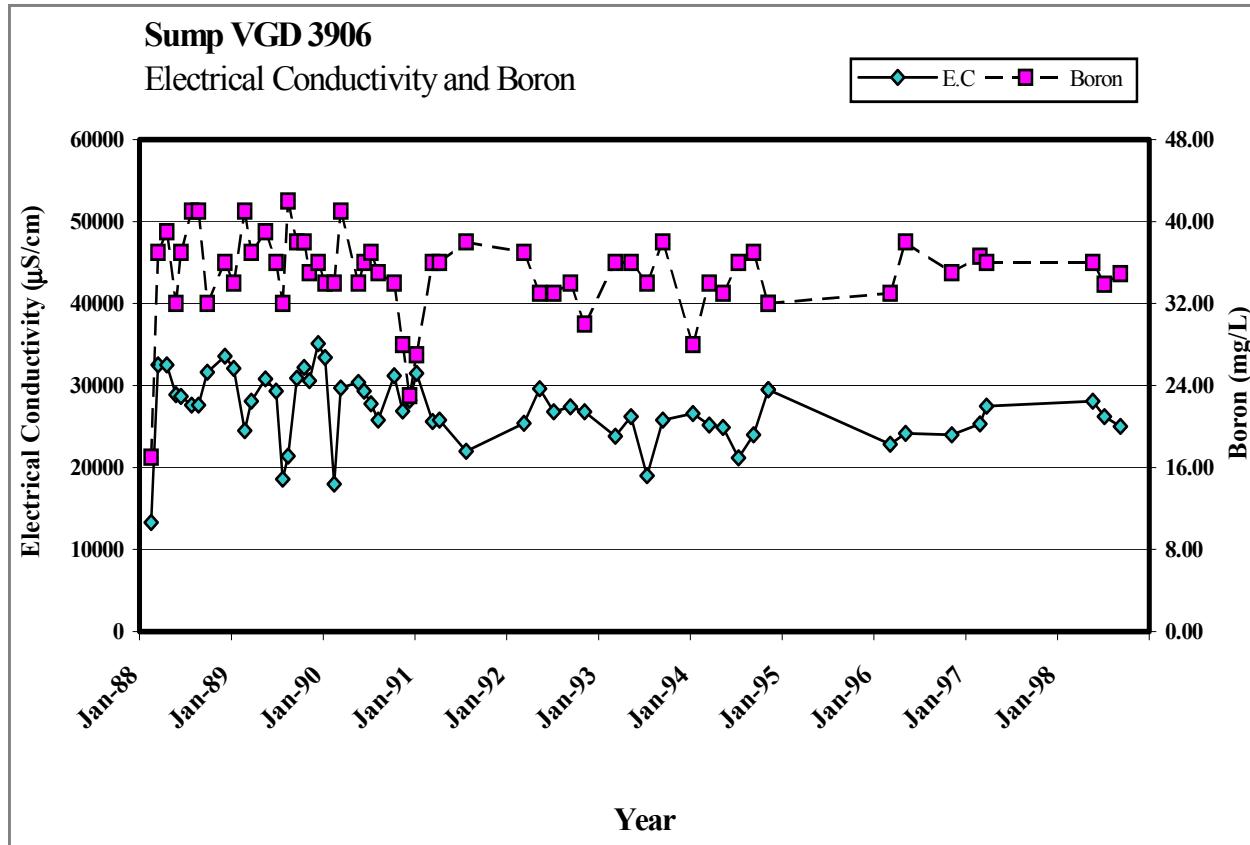
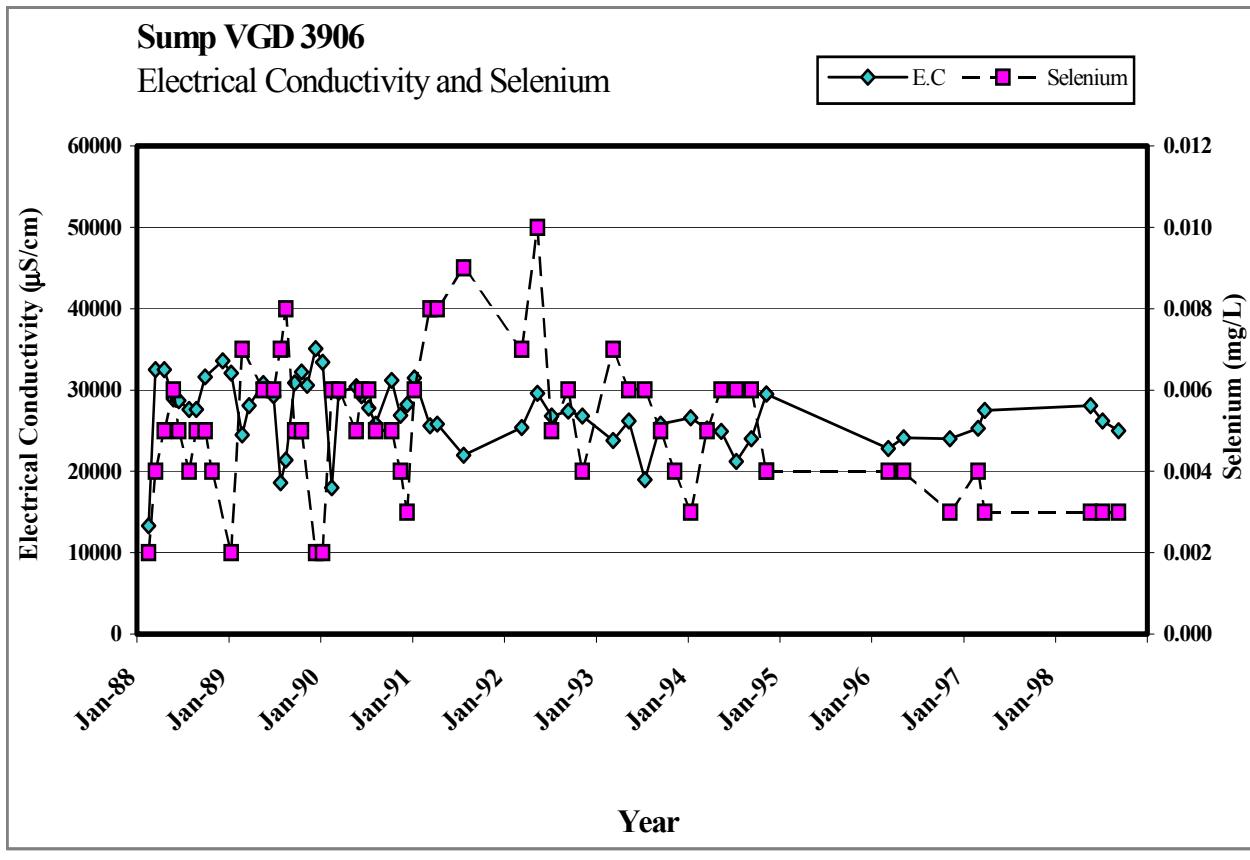
### Sump STC 5436

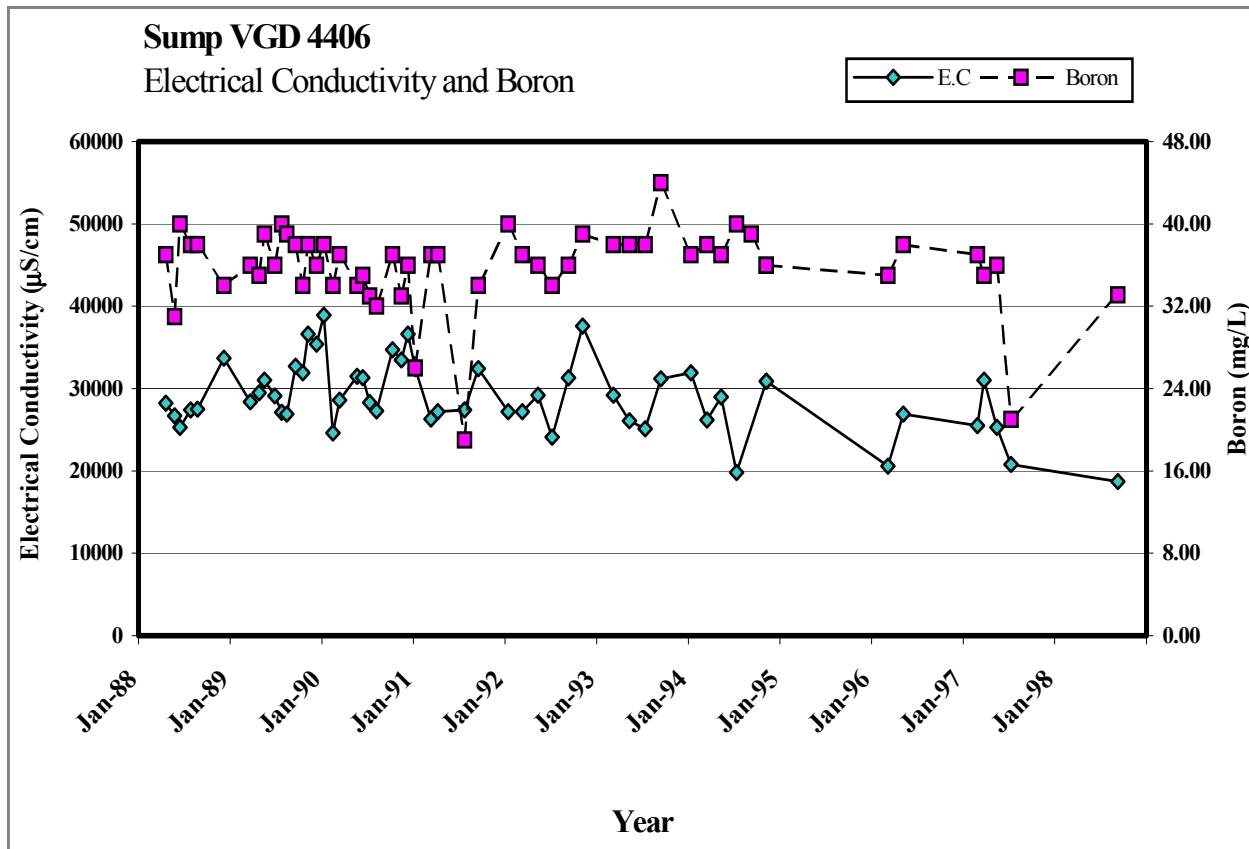
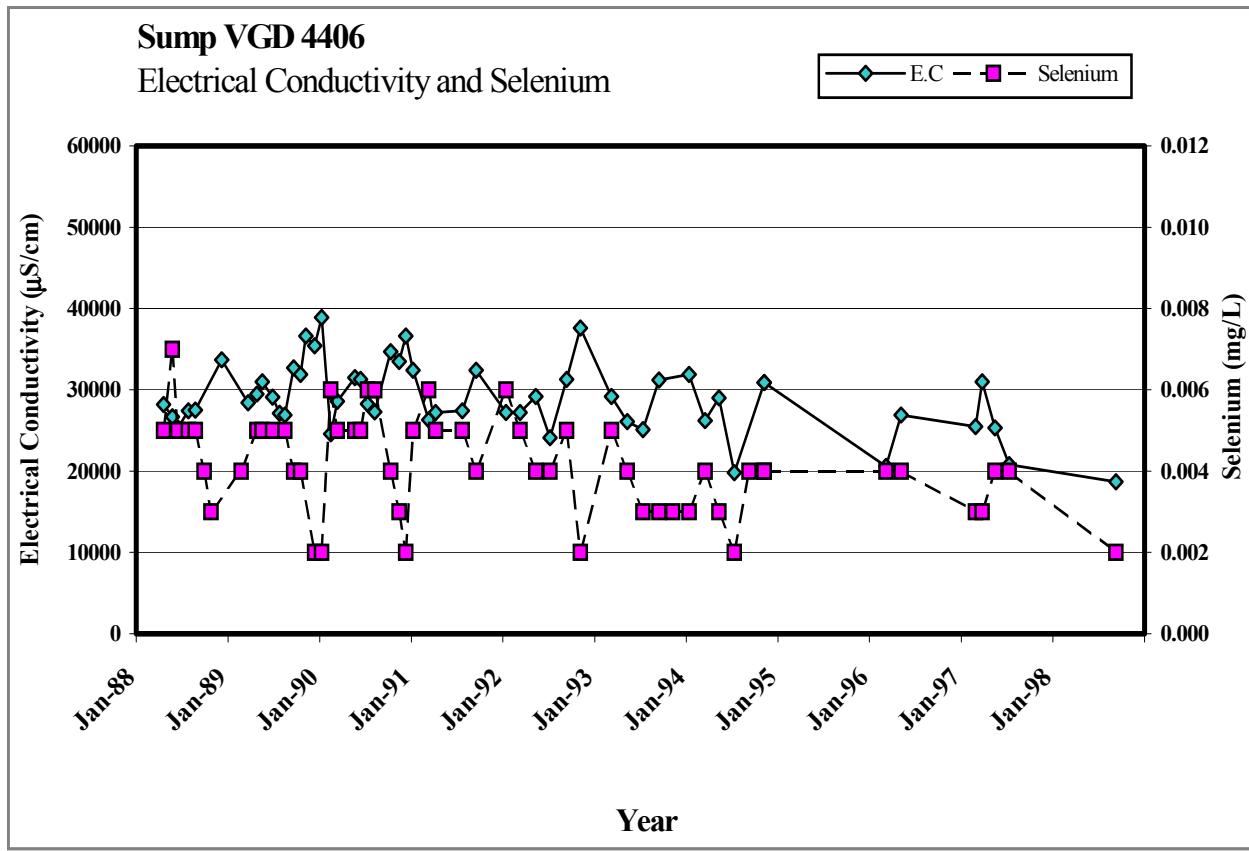
Electrical Conductivity and Boron

— E.C — Boron





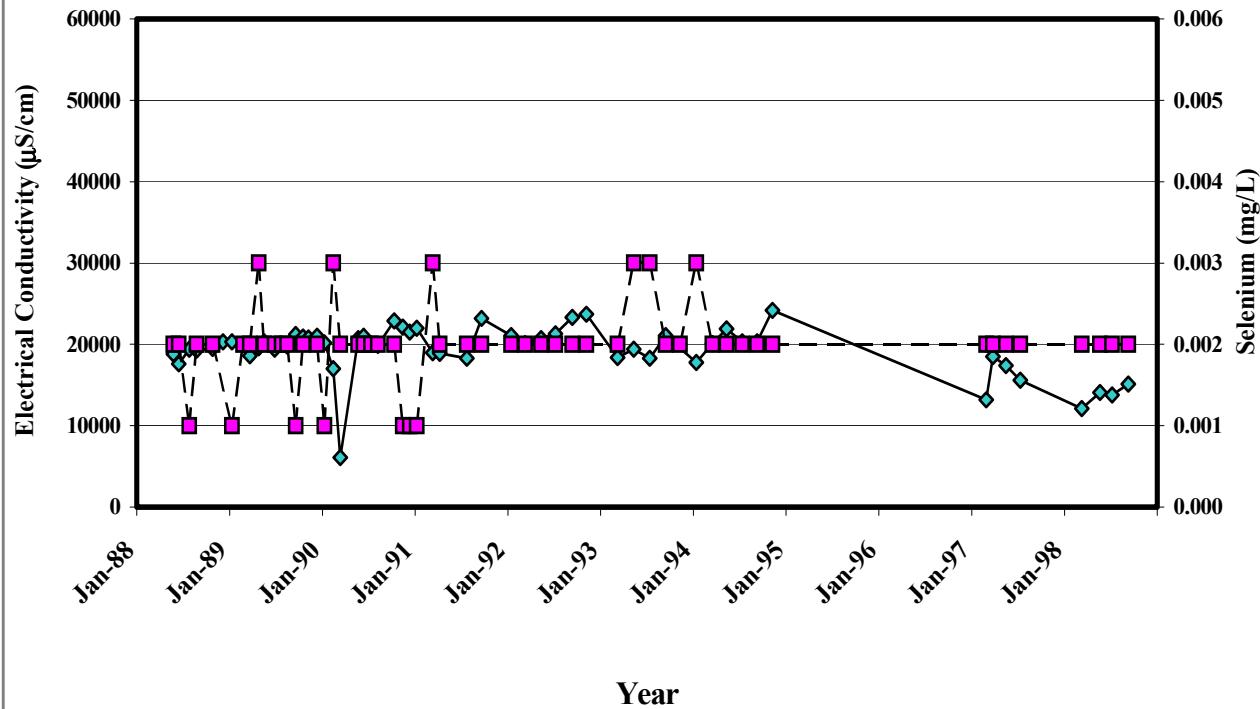




### Sump VGD 5412

Electrical Conductivity and Selenium

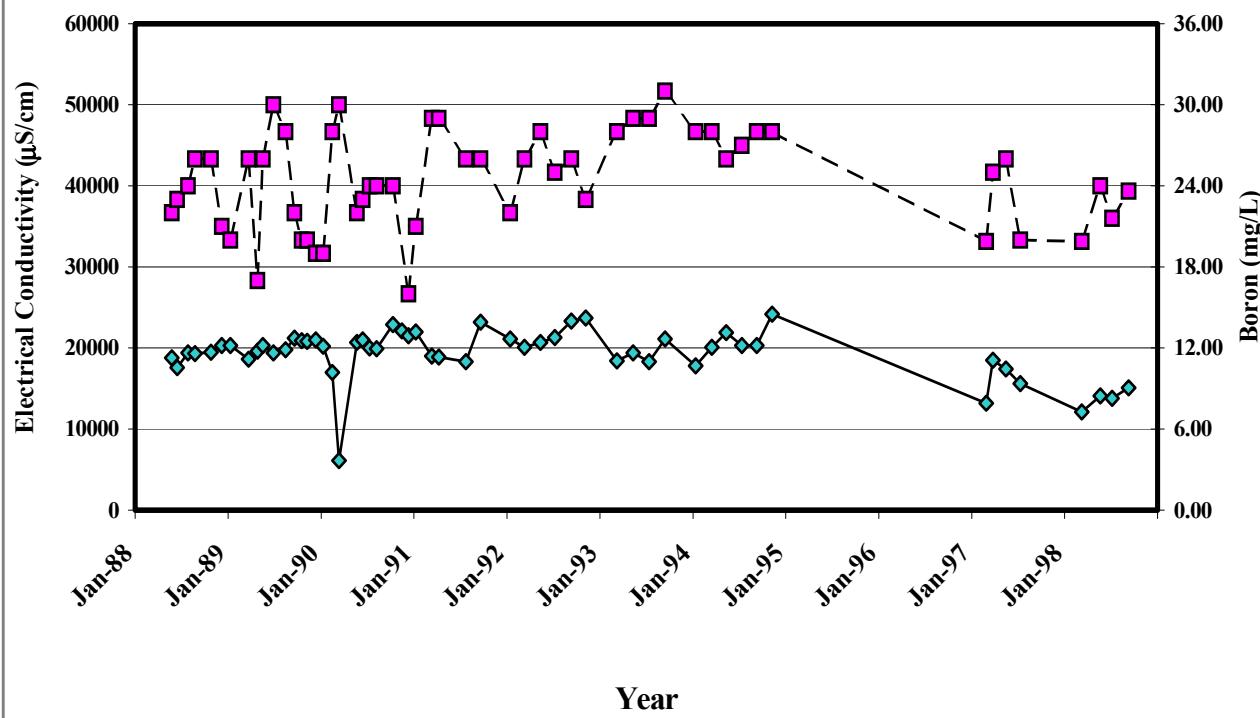
—◆— E.C —■— Selenium



### Sump VGD 5412

Electrical Conductivity and Boron

—◆— E.C —■— Boron



*Insert:* Plate 1. Present & Potential Drainage Problem Areas

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## SYMBOLS and ABBREVIATIONS

Time	Pacific Standard Time on a 24-hour clock
Temp.	Temperature of water at time of sampling in degrees Celsius ( $^{\circ}\text{C}$ ) and degrees Fahrenheit ( $^{\circ}\text{F}$ )
pH	Measure of acidity ( $<7$ ) or alkalinity ( $>7$ ) of water
EC ( $\mu\text{S}/\text{cm}$ )	Electrical Conductivity in microsiemens per centimeter at $25^{\circ}\text{C}$
Mineral constituents:	
B	Boron
Ca	Calcium
$\text{CaCO}_3$	Calcium carbonate
Cl	Chloride
K	Potassium
Mg	Magnesium
Na	Sodium
$\text{NO}_3$	Nitrate (unfiltered)
$\text{SO}_4$	Sulfate
T. Alk.	Total alkalinity
TDS	Gravimetric determination of total dissolved solids at $180^{\circ}\text{C}$
Sum	TDS approximation (for confirmation purposes) determined by addition of the following analyzed constituents: $\text{Ca} + \text{Mg} + \text{Na} + 0.6(\text{CaCO}_3) + \text{SO}_4 + \text{Cl} + \text{NO}_3$
TH	Total hardness
NCH	Noncarbonate hardness
Trace elements:	
Se	Selenium
SAR	Sodium adsorption ratio (developed by U.S. Salinity Laboratory)

## METRIC CONVERSIONS

Quantity	To Convert from Metric Unit	To Customary Unit	Multiply Metric Unit by	To Convert to Metric Unit Multiply Customary Unit by
Length	millimeters (mm)	inches (in)	0.03937	25.4
	centimeters (cm) for snow depth	inches (in)	0.3937	2.54
	metros (m)	feet (ft)	3.2808	0.3048
	kilometers (km)	miles (mi)	0.62139	1.6093
Area	square millimeters ( $\text{mm}^2$ )	square inches ( $\text{in}^2$ )	0.00155	645.16
	square metros ( $\text{m}^2$ )	square feet ( $\text{ft}^2$ )	10.764	0.092903
	hectares (ha)	acres (ac)	2.4710	0.40469
	square kilometers ( $\text{km}^2$ )	square miles ( $\text{mi}^2$ )	0.3861	2.590
Volume	liters (L)	gallons (gal)	0.26417	3.7854
	megalitres	million gallons ( $10^6$ gal)	0.26417	3.7854
	cubic meters ( $\text{m}^3$ )	cubic feet ( $\text{ft}^3$ )	35.315	0.028317
	cubic meters ( $\text{m}^3$ )	cubic yards ( $\text{yd}^3$ )	1.308	0.76455
	cubic decameters ( $\text{dam}^3$ )	acre-feet (ac-ft)	0.8107	1.2335
Flow	cubic meters per second ( $\text{m}^3/\text{s}$ )	cubic feet per second ( $\text{ft}^3/\text{s}$ )	35.315	0.028317
	liters per minute (L/min)	gallons per minute (gal/min)	0.26417	3.7854
	liters per day (L/day)	gallons per day (gal/day)	0.26417	3.7854
	megalitres per day (ML/day)	million gallons per day (mgd)	0.26417	3.7854
	cubic decameters per day ( $\text{dam}^3/\text{day}$ )	acre-feet per day (ac-ft/day)	0.8107	1.2335
Mass	kilograms (kg)	pounds (lb)	2.2046	0.45359
	megagrams (Mg)	tons (short, 2,000 lb)	1.1023	0.90718
Velocity	meters per second (m/s)	feet per second (ft/s)	3.2808	0.3048
Power	kilowatts (kW)	horsepower (hp)	1.3405	0.746
Pressure	kilopascals (kPa)	pounds per square inch (psi)	0.14505	6.8948
	kilopascals (kPa)	feet head of water	0.33456	2.989
Specific Capacity	liters per minute per meter drawdown	gallons per minute per foot drawdown	0.08052	12.419
Concentration	milligrams per liter (mg/L)	parts per million (ppm)	1.0	1.0
Electrical Conductivity	microsiemens per centimeter (FS/cm)	micromhos per centimeter (F mho/cm)	1.0	1.0
Temperature	degrees Celsius (EC)	degrees Fahrenheit (EF)	(1.8 x EC) + 32	(EF - 32) / 1.8

